22 October 1970
Copy No. [redacted]

# CORONA J

# PERFORMANCE EVALUATION REPORT

# MISSION 1109-1 AND 1109-2

# FTV 1657, CR-10

Approved [redacted] Manager
Advanced Projects

Approved [redacted] Manager
Program [redacted]

[redacted]

"C" files – 1109

~~TOP SECRET~~/C

[redacted]

29 October 1970

To: [redacted]

Thru: [redacted]

From: [redacted]

Subject: MISSION 1109 FINAL REPORT (CR-10)

Enclosed is the final evaluation report for Mission 1109.

[redacted] Manager
Advanced Projects

IF ENCLOSURES ... THE CLASSIFICATION
OF THIS DOCUMENT WILL BE CHANGED TO Unclassified

~~TOP SECRET~~/C

[redacted]

FOREWORD

This report details the performance of the payload system during the operational phase of the Program [redacted] Flight Test Vehicle 1657.

Lockheed Missiles and Space Company has the responsibility for evaluating payload performance under the Level of Effort and "J" System contracts.

This document constitutes the final payload test and performance evaluation report for Mission 1109 which was launched 4 March 1970.

CONTENTS

| | Page |
|---|---|
| TITLE PAGE | 1 |
| FOREWORD | 2 |
| CONTENTS | 3 |
| FIGURES | 4 |
| TABLES | 5 |
| INTRODUCTION | 6 |
| SECTION 1 - MISSION SUMMARY | 7 |
| SECTION 2 - PRE-FLIGHT SYSTEM TEST | 14 |
| SECTION 3 - FLIGHT OPERATIONS | 21 |
| SECTION 4 - PHOTOGRAPHIC PERFORMANCE | 40 |
| SECTION 5 - PANORAMIC EXPOSURE | 48 |
| SECTION 6 - IMAGE SMEAR | 68 |
| SECTION 7 - RELIABILITY | 71 |

FIGURES

| | | Page |
|---|---|---|
| 1-1 | Mission 1109 Inboard Profile | 9 |
| 2-1 | Pan Cameras Preflight Resolution | 20 |
| 3-1 | CR-10/1109 Orbit History | 24 |
| 3-2 | CR-10/1109 Perigee Location | 25 |
| 3-3 | Location of Pan Camera Operations | 26 |
| 3-4 | Mission 1109-1 Forward Camera V/h Error | 30 |
| 3-5 | Mission 1109-1 Aft Camera V/h Error | 31 |
| 3-6 | Mission 1109-2 Forward Camera V/h Error | 32 |
| 3-7 | Mission 1109-2 Aft Camera V/h Error | 33 |
| 3-8 | Panoramic Camera Temperatures | 36 |
| 3-9 | Forward Camera Rail Temperatures | 37 |
| 3-10 | Aft Camera Rail Temperatures | 38 |
| 5-1 | Exposure Profile, Fwd Camera Rev 41 | 52 |
| 5-2 | Exposure Profile, Aft Camera Rev 41 | 53 |
| 5-3 | Exposure Profile, Fwd Camera Rev 121 | 54 |
| 5-4 | Exposure Profile, Aft Camera Rev 121 | 55 |
| 5-5 | Exposure Profile, Fwd Camera Rev 235 | 56 |
| 5-6 | Exposure Profile, Aft Camera Rev 235 | 57 |
| 5-7 | Sensitometric Curve, 1109-1 Fwd | 59 |
| 5-8 | Sensit metric Curve, 1109-1 Aft | 60 |
| 5-9 | Sensitometric Curve, 1109-2 Fwd | 61 |
| 5-10 | Sensitometric Curve, 1109-2 Aft | 62 |
| 5-11 | Forward Camera Densities | 63 |
| 5-12 | Aft Camera Densities | 64 |

TABLES

| | | Page |
|---|---|---|
| 4-1 | Evaluation of Bar Target Imagery | 43 |
| 5-1 | Macrodensity Evaluation | 65 |
| 6-1 | Vehicle Attitude and Error Rates | 69 |
| 6-2 | IMC Error and Resolution Limits | 70 |
| 7-1 | Estimated System Reliability | 72 |

INTRODUCTION

This report presents the final performance evaluation of Missions 1109-1 and 1109-2 of the Corona Program. The purpose of this report is to define the performance characteristics of the CR-10 payload system and to identify the source of in-flight anomalies.

The performance evaluation was jointly conducted by representatives of Lockheed Missiles and Space Company (LMSC) and ITEK at the facilities of NPIC and AFSPPF. The off-line evaluation of Corona engineering photography acquired over the United States was performed at the individual contractors plants.

The quantitative data used for this report is obtained from government organizations. The diffuse density data, and MTF/AIM resolution are produced by AFSPPF. The vehicle attitude error values and frame correlation times are made at NPIC who also supply the Processing Summary reports published by [redacted]

Computer programs developed by A/P are utilized to calculate and plot the frequency distribution of the various contributors to image smear to permit analysis and correlation of the conditions of photography to the information content and quality of the acquired pictures. Computer analysis of the exposure, processing and illumination data provides the necessary data to analyze the exposure criteria selected for the mission.

This report contains certain data summarized from [redacted] Processing Summary, and from AFSPPF TERO Report for this mission.

SECTION 1

MISSION SUMMARY

A. MISSION OBJECTIVES

The payload section of Mission 1109, placed into orbit by Flight Test Vehicle 1657 and THORAD Booster (SLV-2H) S/N 041, consisted of two panoramic cameras, one DISIC camera, two Mark 5A recovery capsules and a space structure to enclose the cameras and provide mounting surfaces for all equipment. Figure 1-1 presents an inboard profile of the CR-10 payload system. The Corona "J" system was designed to acquire search and reconnaissance photography of selected areas of the earth from orbital altitudes. A seven day -1 mission and a twelve day -2 mission was planned.

B. MISSION DESCRIPTION

The payload was launched from Vandenberg Air Force Base (VAFB) at 2215:002 (1415:00PST) on 4 March 1970. Ascent and injection were normal and the achieved orbit was within nominal tolerances. Tracking and command support was effected by the Air Force Satellite Control Facility consisting of tracking and command stations at [redacted] under central control of the Satellite Test Center at Sunnyvale, California. Mission 1109-1 consisted of a seven day operation and was completed by air recovery on 11 February 1970. Mission 1109-2 was completed with an air recovery on 23 February 1970 following a twelve day photographic operation.

The comparison of the planned and actual orbit parameters is tabulated as follows:

ORBITAL PARAMETERS

| Parameter | Planned | Orbit 2 Actuals |
|---|---|---|
| Period (Min.) | 88.92 | 88.38 |
| Perigee (N.M.) | 81.3 | 83.7 |
| Apogee (N.M.) | 162.5 | 140.3 |
| Inclination (Deg.) | 88.0 | 88.00 |
| Perigee Latitude (Deg. N) | 33.0 | 57.75 |
| Eccentricity | 0.0115 | .0082 |

Five drag make-up rockets were fired during Mission 1109-1, and two during 1109-2.

C. PANORAMIC CAMERAS

The forward and aft looking instruments operated satisfactorily throughout both missions, and produced good to fair imagery except where degraded by atmospheric haze. Both instruments contained 16,300 feet of standard base type 3404 film which passed into the recovery system without a wrap-up.

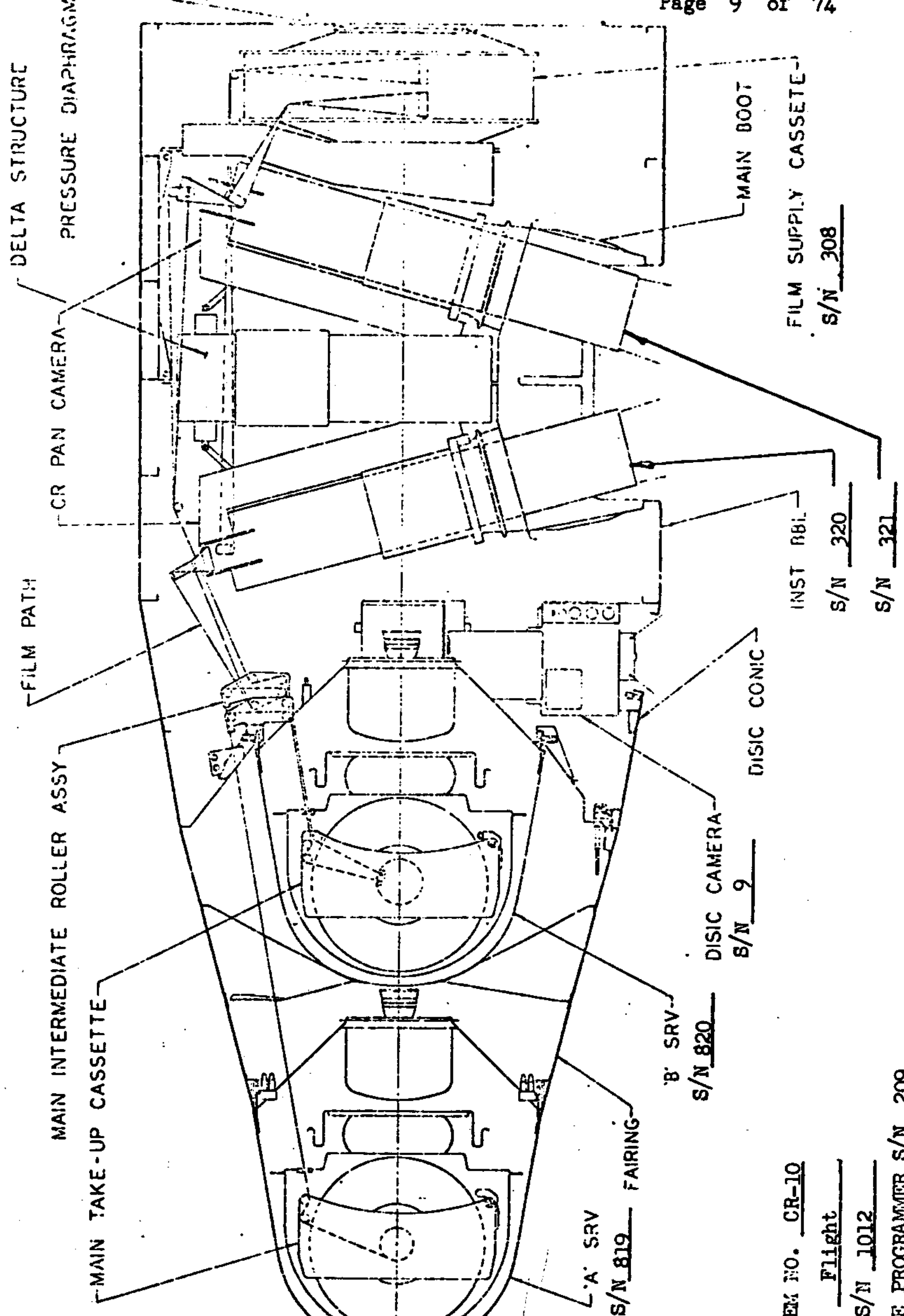
D. DISIC CAMERA

The DISIC camera operated satisfactorily throughout both missions. Although several characteristic markings are present on the record, no significant photographic degradation occurred. Most starboard and port point stellar images were of good quality. The index record is also good and slightly better than that obtained from previous missions.

E. OTHER SUB-SYSTEMS

The pressure make-up unit, the clock and the thermal control subsystems performed satisfactorily, as did the digital shift register portion of the command system V/h and exposure programmer.

FIGURE 1-1: INBOARD PROFILE




SYSTEM NO. CR-10
TEST Flight
PMU S/N 1012
SLOPE PROGRAMMER S/N 209
CLOCK S/N 628
SWITCH PROGRAMMER S/N 212

F. COMPONENT IDENTIFICATIONS AND SETTINGS

1. Forward Looking Panoramic Camera

a. Component Assignment

| Component | Serial No. |
|---|---|
| Main Camera | 321 |
| Main Camera Lens | I211 |
| Supply Horizon Camera Lens | E23769 |
| Take-up Horizon Camera Lens | E23775 |

b. Camera Data and Flight Settings

Main Camera:

| | |
|---|---|
| Lens | 24" f/3.5 |
| Slit Widths | |
| $S_1$ | 0.180" |
| $S_2$ | 0.214" |
| $S_3$ | 0.261" |
| $S_4$ | 0.145" |
| F/S | 0.210" |
| Filter Types | |
| Primary | Wratten 25 |
| Secondary | Wratten 23A |
| Film Types | Eastman Type 3404 (16,300 ft.) |

Supply (Port) Horizon Camera:

| | |
|---|---|
| Lens | 45.4 mm f/6.3 |
| Aperture Setting | f/6.3 |
| Exposure Time | 1/100 second |
| Filter Type | Wratten 25 |

Take-up (Starboard) Horizon Camera:

| | |
|---|---|
| Lens | 45.4 mm f/6.3 |
| Aperture Setting | f/8.0 |
| Exposure Time | 1/100 second |
| Filter Type | Wratten 25 |

2. Aft Looking Panoramic Camera

a. Component Assignment

| Component | Serial No. |
|---|---|
| Main Camera | 320 |
| Main Camera Lens | I212 |
| Supply Horizon Camera Lens | E23803 |
| Take-up Horizon Camera Lens | E23794 |

b. Camera Data and Flight Settings

Main Camera:

| | |
|---|---|
| Lens | 24" f/3.5 |
| Slit Widths | |
| $S_1$ | 0.150" |
| $S_2$ | 0.197" |
| $S_3$ | 0.238" |
| $S_4$ | 0.267" |
| F/S | 0.164" |
| Filter Types | |
| Primary | Wratten 23A |
| Secondary | Wratten 25 |
| Film Types | |
| Primary | Eastman Type 3404 (16,300 ft.) |

Supply (Starboard) Horizon Camera:

| | |
|---|---|
| Lens | 45.3 mm/f6.3 |
| Aperture Setting | f/8.0 |
| Exposure Time | 1/50 second |
| Filter Type | Wratten 25 |

Take-up (Port) Horizon Camera:

| | |
|---|---|
| Lens | 45.4 mm f/6.3 |
| Aperture Setting | f/6.3 |
| Exposure Time | 1/100 second |
| Filter Type | Wratten 25 |

3. <u>DISIC Camera</u>

a. Component Assignment

| Component | Serial No. |
|---|---|
| Camera | 009 |
| Index Reseau | 112 |
| Stellar Reseaus | |
| Port | 13P |
| Starboard | 9 |

b. Camera Data and Flight Settings

Stellar Cameras:

| | |
|---|---|
| Lens | 3.0 in.f/2.8 |
| Exposure Time | 1.5 seconds |
| Filter Type | 3401 (2000 ft.) |
| Film Type | Eastman Type 3401 (2000 ft.) |

Index Camera:

| | |
|---|---|
| Lens | 3 in. f/6.3 |
| Exposure Time | 1/500 second |
| Filter Type | Wratten 12 |
| Film Type | Eastman 3400 (2200 ft.) |

SECTION 2

PRE-FLIGHT SYSTEMS TEST

The CR payload systems are subjected to a sequential series of tests required to demonstrate a satisfactory confidence level in the flightworthiness of the systems. These tests include static verification, dynamic performance, operation in simulated thermal-altitude environment, light leak evaluation and dynamic photographic performance measurements. Significant baselines experienced on CR-10 during pre-flight testing are as follows:

A. ENVIRONMENTAL TESTING

Payload system CR-10 was tested twice in the environmental HIVOS chamber; in standard configuration from October 24 through October 30, 1969, and again from January 8 through January 12, 1970.

1. HIVOS Test No. 1

Pan Instruments

Standard base 3404 film was used in both forward and aft instruments for the -1 mission simulation. Special color film, SO-242 was spliced onto the tail end of both supplies. Standard base 3400 film was used on both the DISIC Terrain and Stellar units.

With the PMU disabled, at a pressure of 3 to 5 microns of mercury, the 3404 film showed start-up corona, and was found to be within acceptance levels. Upon enabling the PMU, no marking was evidenced.

Unacceptable corona (2 $\pi$) was produced by instrument No. 1 at pressures between 11 and 36 microns during pressure sweeps.

Minimal start-up corona occurred on several operations in which color film was used during inactive PMU periods. Both instruments showed no marking during PMU operation or during pressure sweeps on No. 2 instrument. Instrument No. 1 went into fail-safe prior to pressure sweeps.

Instrument No. 1 sheared a pin in the output metering roller 1739 frames into the -2 mission. The sheared pin was attributed to a splice peel-back. Because of this failure, pressure sweeps on the SO-242 were not obtained.

DISIC Camera

The DISIC Terrain manifested no corona during the -1 mission, but 46% of the -2 mission was marked when pressures measured less than 10 microns of mercury.

The DISIC Stellar camera showed corona on all starboard formats of the -1 mission. Approximately 70% of the starboard and port formats of the -2 mission were marked. Some of this marking was attributable to the SLP data head clamping pressure.

Except as noted, the DISIC performed satisfactorily throughout the -1 mission, but the Stellar unit, after DISIC cut and splice, indicated slow "B" take up. Although the metering continued to degrade during the -2 mission, the mission was completed.

Command System

The AGE command system utilized a programmed "H" timer tape to simulate all Uncle commands, except as follows: PMU Enable/Disable, DSR Load Enable, Load and Logic Enable (Uncle 200-245). These commands were issued manually. Only minor problems occurred in commanding and these were corrected by repunching the "H" timer tape.

Both the V/h programmer (Slope) and exposure programmer (Switch) operated satisfactorily through the test. The computed accuracy of these functions was found to be within design specification.

The Clock/IRIG "C" accuracy when computed over a 5 day period, was within the 10 ms/day criteria.

The PMU performed normally.

2. HIVOS Test No. 2

Pan Instruments

The CR-10 payload was tested the second time in the HIVOS chamber between 8 and 12 January 1970. Both panoramic cameras were loaded with standard thin base 3404 film. Start-up corona was evident at pressures from 2.2 to 4.4 microns, but the density and extent of the marking was found to be within acceptable levels. Film from No. 1 pan camera (S/N 320) manifested a two inch square mark, which correspondingly occurred at 6.5 microns, but being trivial, was waived. Pan camera No. 2 (S/N 321) manifested corona during the pressure sweep sequence (86-98 microns), but, the marking density was low. In as much as the corona was light and also beyond the PMU normal pressure range, these markings were also waived.

The main instruments operated satisfactorily throughout the second HIVOS test except:

a. The specification limit of 100 ms between centers of format was exceeded when instrument No. 2 required 450 ms longer to actuate the first c/f switch. The High Efficiency Amplifier, HEA, is suspect.

b. The slit drive was sluggish on instrument No. 1 at altitude. Further chamber tests are contemplated.

<u>DISIC</u>

Generally, satisfactory performance throughout the test. A new take-up unit was used during this test. The terrain film was generally free from corona marking. Some electrostatic discharges along the film edge affected 15 frames. It is uncertain whether this marking occurred during test or retrieval, nevertheless it was within acceptable levels. The stellar film had a + density streak for 122 frames and may have been corona. The density of the streak was 0.06 above reseau fog in formats. Between formats, the density of the streak did not exceed 0.02 above base fog. 6% of the test formats were affected but, the marking was within acceptance levels.

<u>Subsystem Performance</u>

No anomales in performance were experienced in either the V/h or exposure programmer, both operated satisfactorily throughout the test. When the cycle rates were computed, they were found to be within specifications.

The Clock/IRIG "C" accuracy check over a 3 day period, when computed, was found to have an error less than the 10 ms/day criteria.

The PMU operated normally throughout the test.

B. RESOLUTION TEST

Three weeks of resolution testing on CR-10 were concluded on December 13. Some initial difficulties in ascertaining the location of peak focus were resolved by revised criteria provided by ITEK.

The results of the thru focus resolution tests on the pan instruments showed the following characteristics:

Aft-looking Instrument S/N 320 -

Maximum low contrast resolution 165 lines/mm at 0.0006 peak focal position.

Forward-looking Instrument S/N 321 -

Maximum low contrast resolution 208 lines/mm at 0.0003 peak focal position.

The final test data for both instruments is shown in Figures 2-1 and 2-2. Both instruments met the system requirements specification.

C. LIGHT LEAK TEST

The photomultiplier light search test conducted after flight loading indicated that the system was free of any light leaks. Evaluation of the flight test specimens that were later retrieved and processed also showed that the system was light tight.

D. FLIGHT LOADING AND CERTIFICATION

The DISIC #9 was loaded and installed in the CR-10 system on 24 February 1970. The pan CR-10 system was also loaded on 24 February 1970. Film samples taken from both DISIC and pan systems were processed and evaluated. They were free of physical defects and the photographic characteristics were satisfactory. All functions were normal, and as noted in the preceding paragraph, the light leak search test showed that the system was light tight.

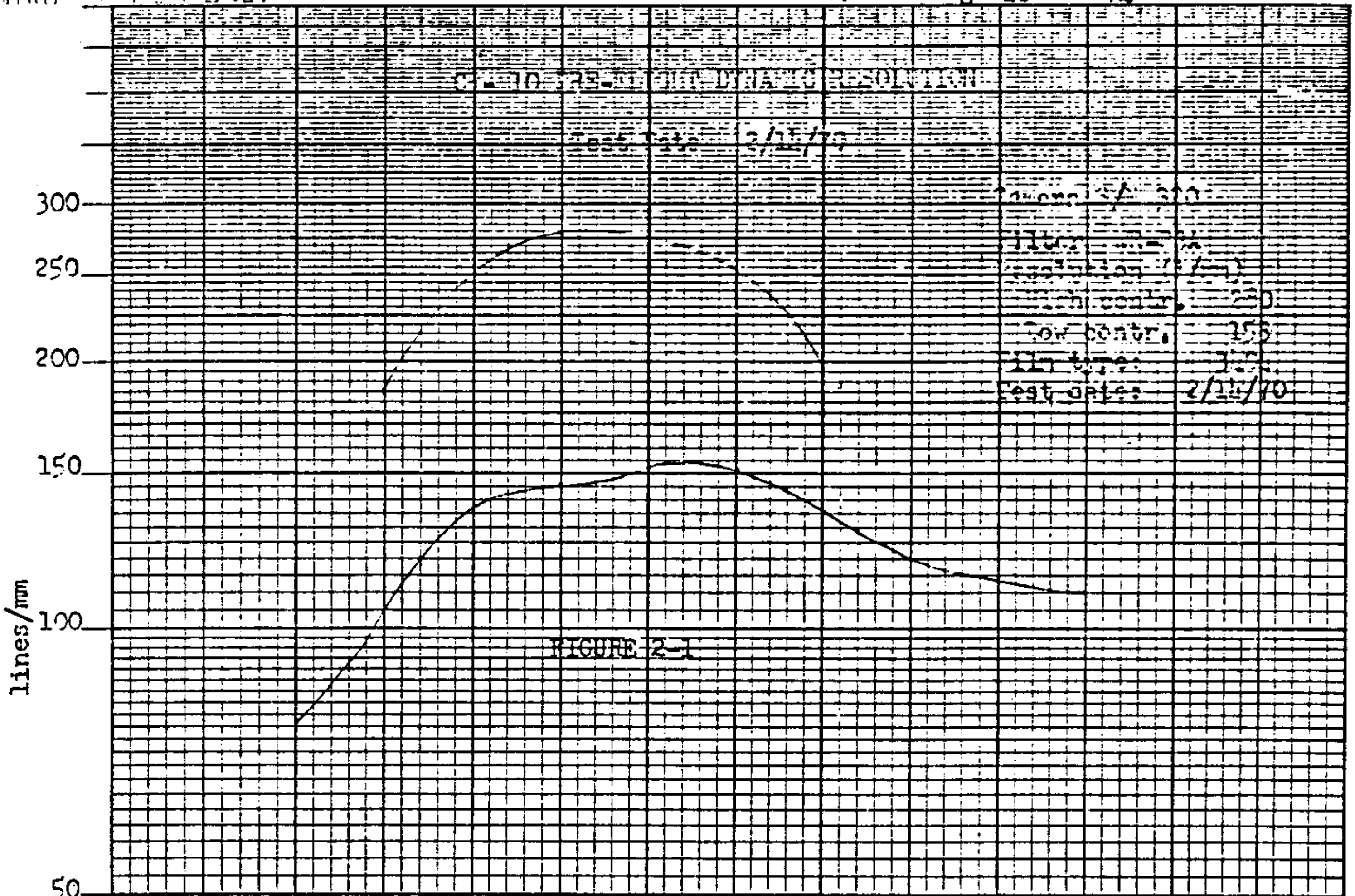



FIGURE 2-1

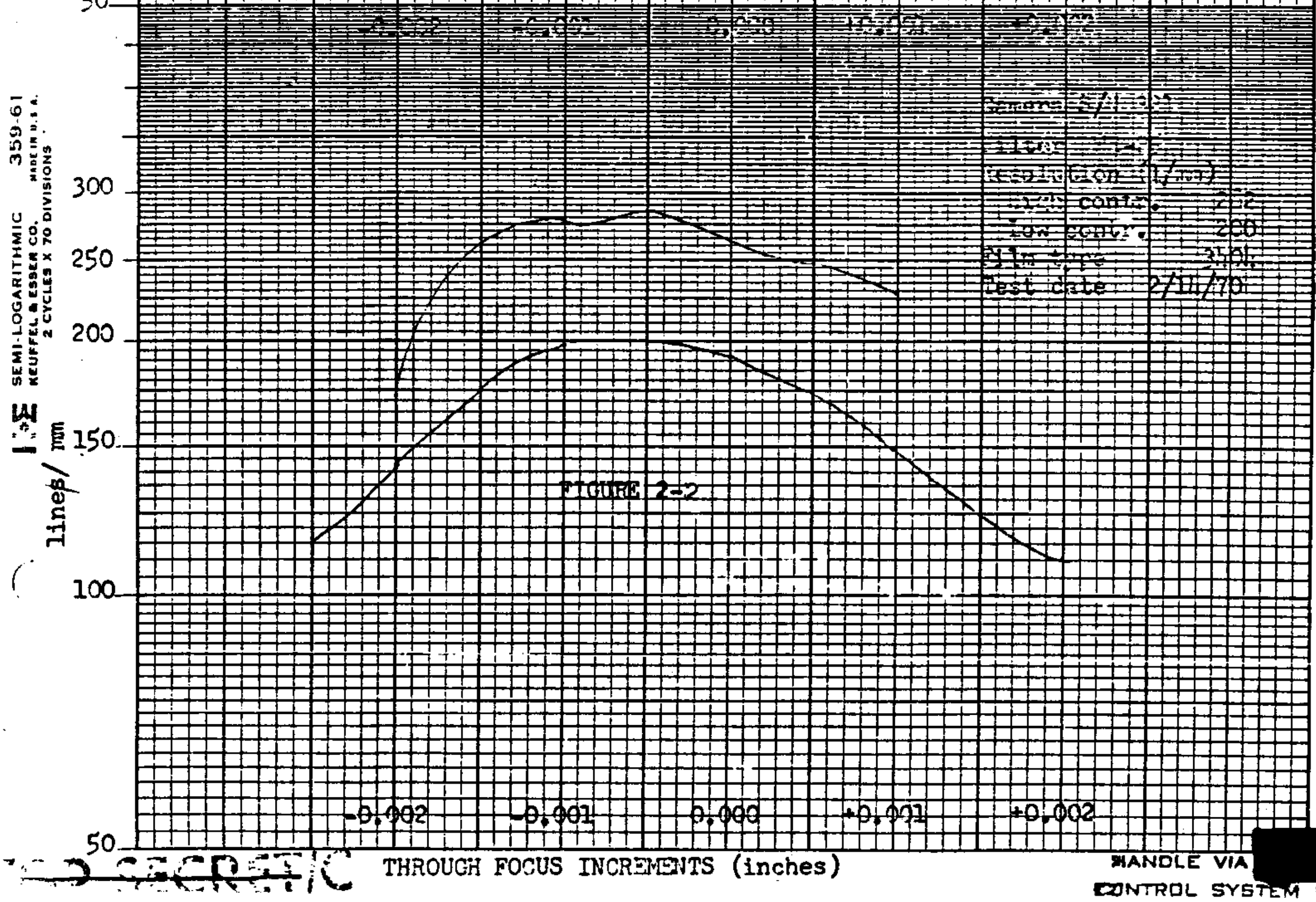



FIGURE 2-2

THROUGH FOCUS INCREMENTS (inches)

SECTION 3

FLIGHT OPERATIONS

A. SUMMARY

Lift-off for Vehicle 1657 occurred at 14:07:00 GMT on 4 March 1970, using the SLC-3 west pad, from Vandenberg. The planned mission objective of 19 days was concluded with successful recoveries of the -1 mission after 7 days and the -2 mission after an additional 12 days.

Reset (door ejection), A/P to Orbit Mode, Instrumentation Switchover, and Panoramic Camera Transfer to Orbit Mode occurred as programmed.

Because of a "cold burn", the booster went to fuel depletion, and the velocity meter shut down occurred seven seconds late. The Agena made up all but 48FPS of the 233 FPS which the "cold burn" caused. As a result of this disparity in velocity, the orbital period was approximately 30 seconds shorter than predicted, making the attained orbit outside the 3 $\sigma$ dispersion.

Both panoramic cameras operated normally, throughout both missions exhausting their film supply during Revs 300 and 301 for instruments 320 and 321 respectively.

The DISIC system also functioned satisfactorily during both missions. The DISIC terrain film supply was exhausted during Rev 296 and the last titled stellar format occurred during Rev 300. Cut, splice and transfer transpired as programmed and were satisfactory.

The Real Time Command (RTC) system operation, utilizing both "Uncle" and "Silo" command systems operated satisfactorily throughout the flight. The Digital Storage Register (DSR) performed satisfactorily throughout the flight.

A satisfactory match of the required FMC was maintained during both the -1 and -2 missions.

The clock system operated normally and satisfactorily. Satisfactory clock/system time correlation was obtained.

The slit control programmer operated satisfactorily during both missions, however, the majority of operations were made with the control in a fixed slit position.

PMU operation throughout the flight was satisfactory. The gas consumption rate was such that, at the conclusion of the -2 mission, the gas supply had not depleted.

The SRV tape recorder tape from the -1 mission experienced a high loss of synchronization in the ADAPS processer. The tape recorder in the -2 mission, however, performed satisfactorily.

The -1 mission recovery capsule was successfully recovered by air catch. All re-entry events were within tolerance. The impact was within tolerance, although not as predicted.

The -2 recovery was also successfully recovered by air catch. All re-entry events were within tolerance as was the point of impact.

DMU Operation

Seven DMU rockets were used for period control and orbit adjust to satisfactorily maintain ground tracks. Rockets #1 and #2 were fired on Revs 3 and 4 for orbit adjust of approximately 30 seconds which resulted from the "cold booster". Rockets 3, 4 and 5 were fired on Revs 27, 60 and 87 respectively with nominal performance and gas usage. Rockets 6 and 7 were fired during the -2 mission on Revs 150 and 223 again with nominal performance and gas usage.

A compromise was necessary during Rev 206 to achieve a desired perigee altitude and/or location to allow the ground track to cover a desired target. The compromise did not degrade mission performance.

The following is a summary of the DMU firings:

| Rocket No. | Pass Fired | System Time (Sec.) | Period Change (Sec.) | Velocity Change Ft/Sec. | Period at Firing |
|---|---|---|---|---|---|
| 1 | 3 | 07798 | 15.10 | 25.22 | 88.24 |
| 2 | 4 | 15523 | 10,44 | 16.61 | 88.38 |
| 3 | 27 | 51372 | 15.50 | 24.70 | 88.40 |
| 4 | 60 | 548895 | 10.60 | 16.95 | 88.43 |
| 5 | 87 | 26814 | 15.62 | 24.80 | 88.42 |
| 6 | 150 | 16020 | 17.50 | 27.92 | 88.39 |
| 7 | 223 | 59586 | 17.39 | 27.77 | 88.32 |

Figures 3-1 and 3-3 are plots of orbit history and operation distribution data.

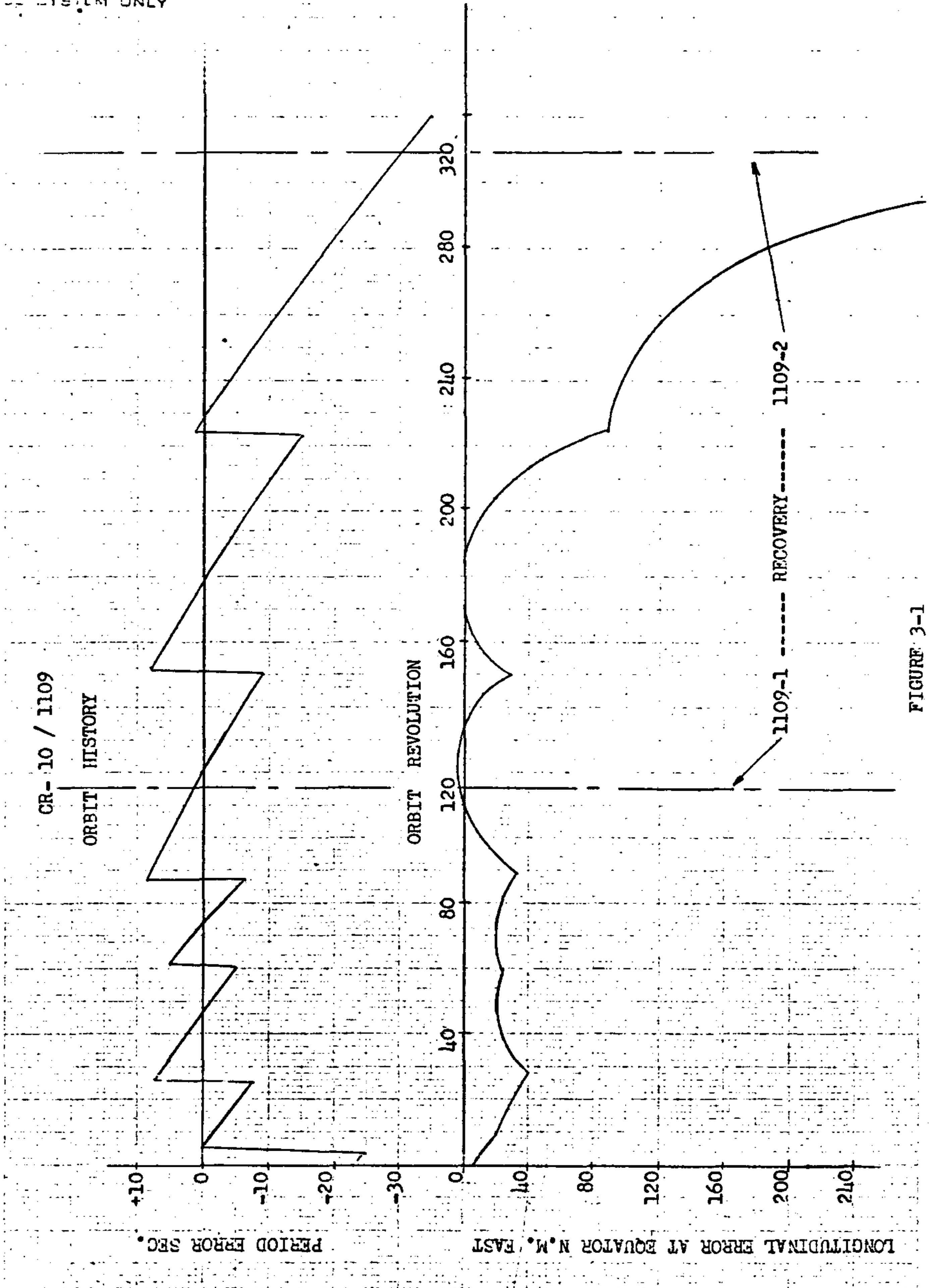
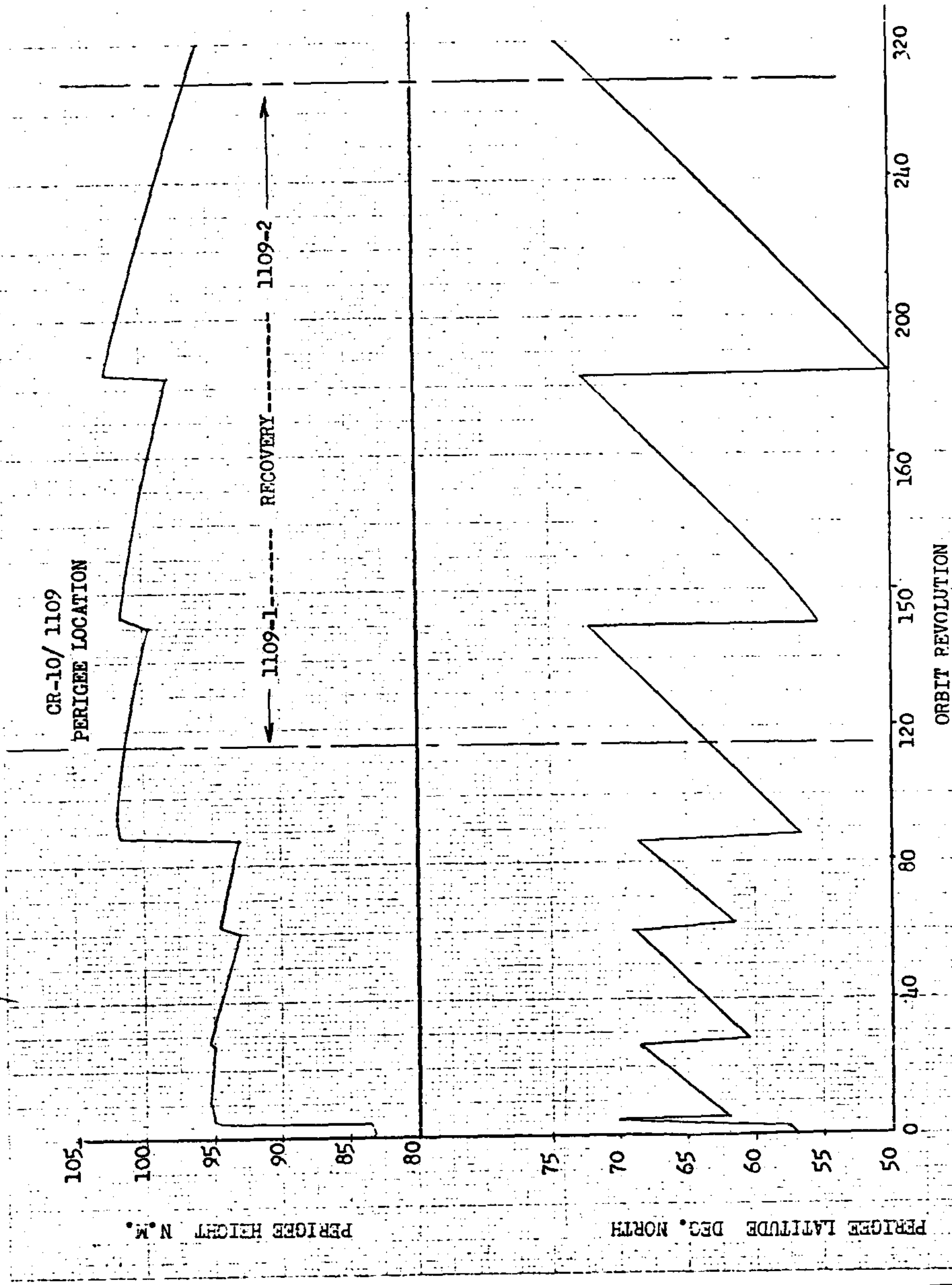

CR- 10 / 1109
ORBIT HISTORY
ORBIT REVOLUTION
PERIOD ERROR SEC.
LONGITUDINAL ERROR AT EQUATOR N.M. EAST
1109-1 ------ RECOVERY ------ 1109-2
+10
0
-10
-20
-30
0
40
80
120
160
200
240
40
80
120
160
200
240
280
320

FIGURE 3-1



CR-10/ 1109
PERIGEE LOCATION
1109-1
RECOVERY
1109-2
ORBIT REVOLUTION
0
40
80
120
150
160
200
240
320
PERIGEE HEIGHT N.M.
105
100
95
90
85
80
PERIGEE LATITUDE DEG. NORTH
75
70
65
60
55
50


FIGURE 3-2

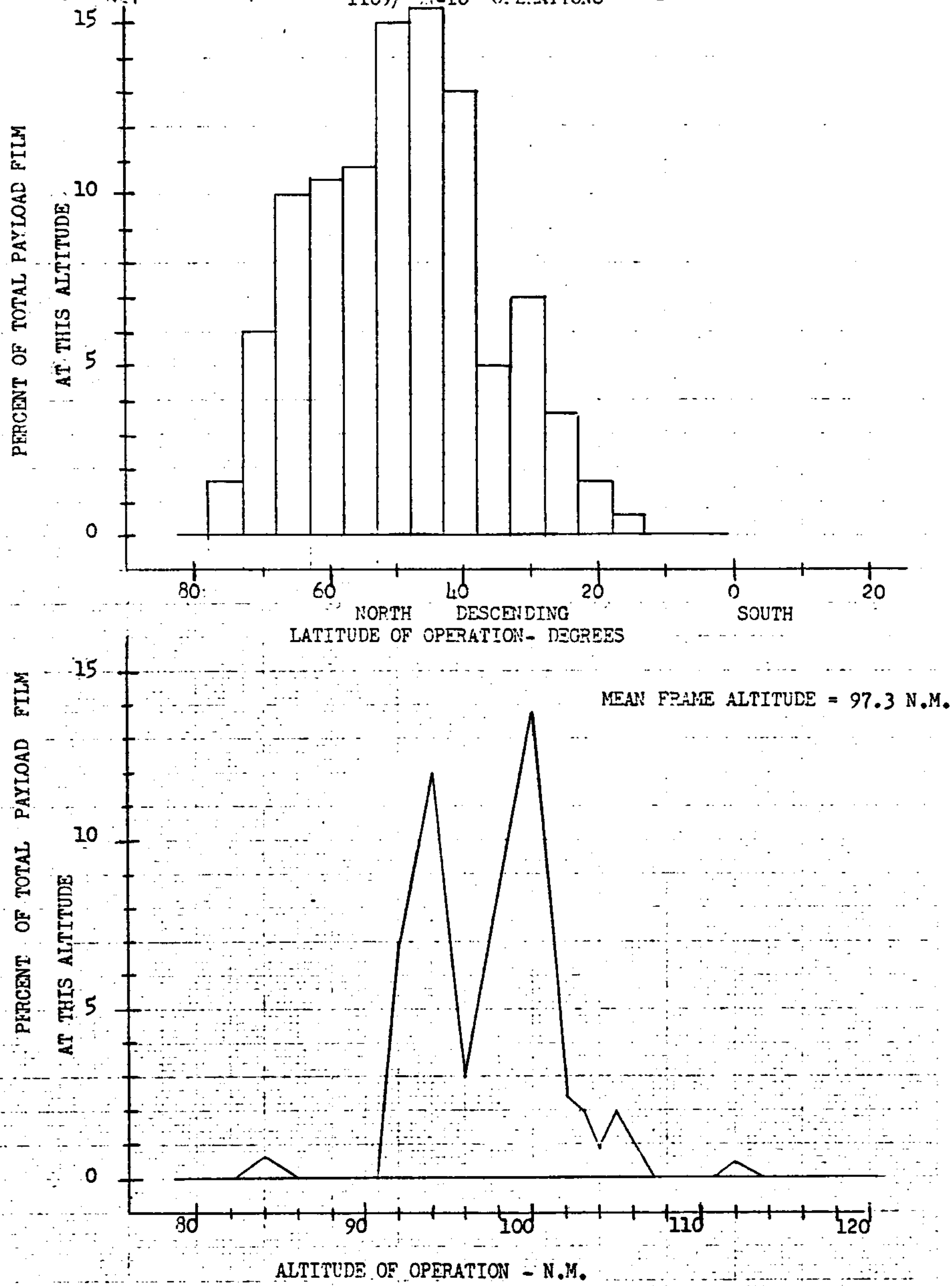

PERCENT OF TOTAL PAYLOAD FILM
AT THIS ALTITUDE
15
10
5
0
80
60
40
20
0
20
NORTH DESCENDING
SOUTH
LATITUDE OF OPERATION- DEGREES
PERCENT OF TOTAL PAYLOAD FILM
AT THIS ALTITUDE
15
10
5
0
MEAN FRAME ALTITUDE = 97.3 N.M.
80
90
100
110
120
ALTITUDE OF OPERATION - N.M.

FIGURE 3-3

B. ORBITAL PARAMETERS

The following tabulation describes the orbital parameters achieved, as a result of the booster "cold burn", as compared to those predicted.

| Parameter | Predicted | Tolerance | Actual STC | Actual APF |
|---|---|---|---|---|
| Period (Min) | 88.92 | +0.92, -0.45 | 88.41 | 88.38 |
| Perigee (nm) | 81.3 | +6, -6 | 84.1 | 83.7 |
| Apogee (nm) | 162.5 | +11, -19 | 141.3 | 140.3 |
| Eccentricity | 0.0115 | +0.0020, -0.0031 | 0.0078 | 0.0082 |
| Inclination (Deg) | 88.00 | +0.22, -0.16 | 88.01 | 88.00 |
| Argument of Perigee(Deg) | 147 | +47, -46 | 120.1 | 122.0 |
| Regression Rate (Deg/Rev) | 22.31 | ------- | 22.18 | 22.23 |
| Perigee Latitude (Deg N.) | 33 | +48, -49 | ----- | 57.75 |

C. PANORAMIC CAMERA PERFORMANCE

Both panoramic cameras #320 and #321 exhibited normal film transport characteristics and operated satisfactorily throughout the flight. Each of the cameras was loaded with 16,300 feet of standard base type 3404 film, which passed the tag end into the recovery systems without a film wrap-up. Film depletion for camera #320 occurred on frame 53 during Rev 300, and frame 9 during Rev 301 of panoramic camera #321.

| | Panoramic Camera #320 | Panoramic Camera #321 |
|---|---|---|
| Sample | 20 | 30 |
| Pre-Launch | 123 | 124 |
| -1 Mission | 3010 | 3005 |
| -2 Mission | 3030 | 3046 |

D. DISIC PERFORMANCE

The DISIC camera performed satisfactorily throughout the -1 and -2 missions. The terrain camera was loaded with 2200 feet of type 3400 and the stellar camera with 2000 feet of type 3401 film.

Cut, splice and transfer to the second recovery system were commanded by KIK-SILO 39 on Rev 109. All events occurred as programmed satisfactorily. The terrain instrument depleted its film during frame 12 on Rev 296. The stellar instrument film was not exhausted at the -2 mission recovery.

Film consumption, in frames, occurred as listed:

| | Stellar | Terrain |
|---|---|---|
| Sample | 20 | 24 |
| Pre-Launch | 60 | 108 |
| -1 Mission | 2406 | 2427 |
| -2 Mission | 2780 | 2681 |
| Total | 5266 | 5240 |

E. INSTRUMENTATION AND COMMAND SYSTEM PERFORMANCE

The command and instrumentation system utilized the Space Ground Link Equipment (SGLE). Pan camera ON-OFF in the normal operating mode utilized a cascade of H timer stored commands enabled by the Digital Shift Register (DSR). An emergency operating mode capability also existed.

Both the command and instrumentation systems performed satisfactorily throughout both missions. Mission 1109 was the first flight to utilize SILO 327 operational-diagnostic data selection.

F. FORWARD MOTION COMPENSATION PERFORMANCE

A match of the required FMC to the actual attained was within the prescribed limits of less than ± 1% for most operations. The mean error for the -1 mission was -0.30% for a total of 2946 frames and the 1$\sigma$ dispersion was 0.87%. The mean error for the -2 mission was -0.27% for a total of 3155 frames and the 1 $\sigma$ dispersion was 0.66%.

Figures 3-4 and 3-5 show the central tendency of the V/h error for the -1 mission. When compared with Figures 3-6 and 3-7, which represent the -2 mission, the dispersion is greater. The difference in dispersion is a result of the "cold burn" of the booster. Later in Revs 3 and 4, DMU rockets #1 and #2 were fired to correct the period and orbit parameters.

Initial flight FMC settings for the eccentricity function period was 3900 seconds and the delay step increment was set at 50 seconds. The oblateness function period was set at 2622 seconds with a gain factor of 0.0998.

Both the oblateness and yaw functions were normal and satisfactory.

G. EXPOSURE CONTROL SYSTEM PERFORMANCE

The exposure control programmer functioned satisfactorily throughout both missions although the majority of operations were taken in fixed slit positions because of orbit exposure requirements.

Initial settings were $T_1$ 60 seconds, $T_2$ (DISIC exposure to 1/500) 380 seconds, $T_3$ (Slit position 3 duration) 400 seconds, $T_4$ (Slit position 2 duration) 40 seconds, $T_5$ (DISIC exposure to 1/250) 100 seconds and $T_6$ ($420-T_1$) = 360 seconds.

FRAMES 1-3 OF EACH OP OMITTED 90 PERCENT = 1.55

Y V/H RATIO ERROR - PERCENT (X) VERSUS FREQUENCY - PERCENT (Y)

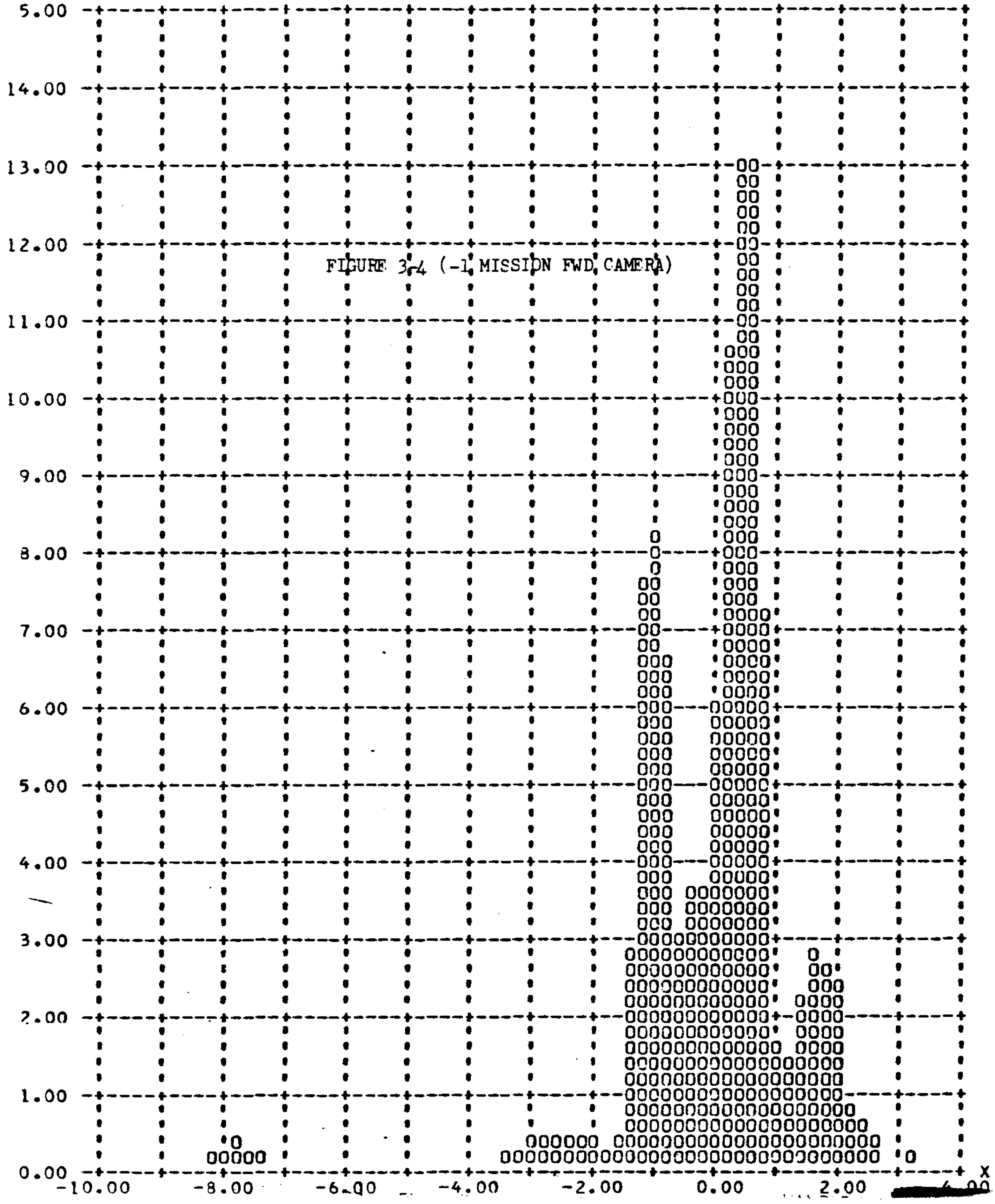



FIGURE 3-4 (-1 MISSION FWD CAMERA)

[redacted]

FRAMES 1-3 OF EACH OP OMITTED 90 PERCENT = 1.56

Y V/H RATIO ERROR - PERCENT (X) VERSUS FREQUENCY - PERCENT (Y)

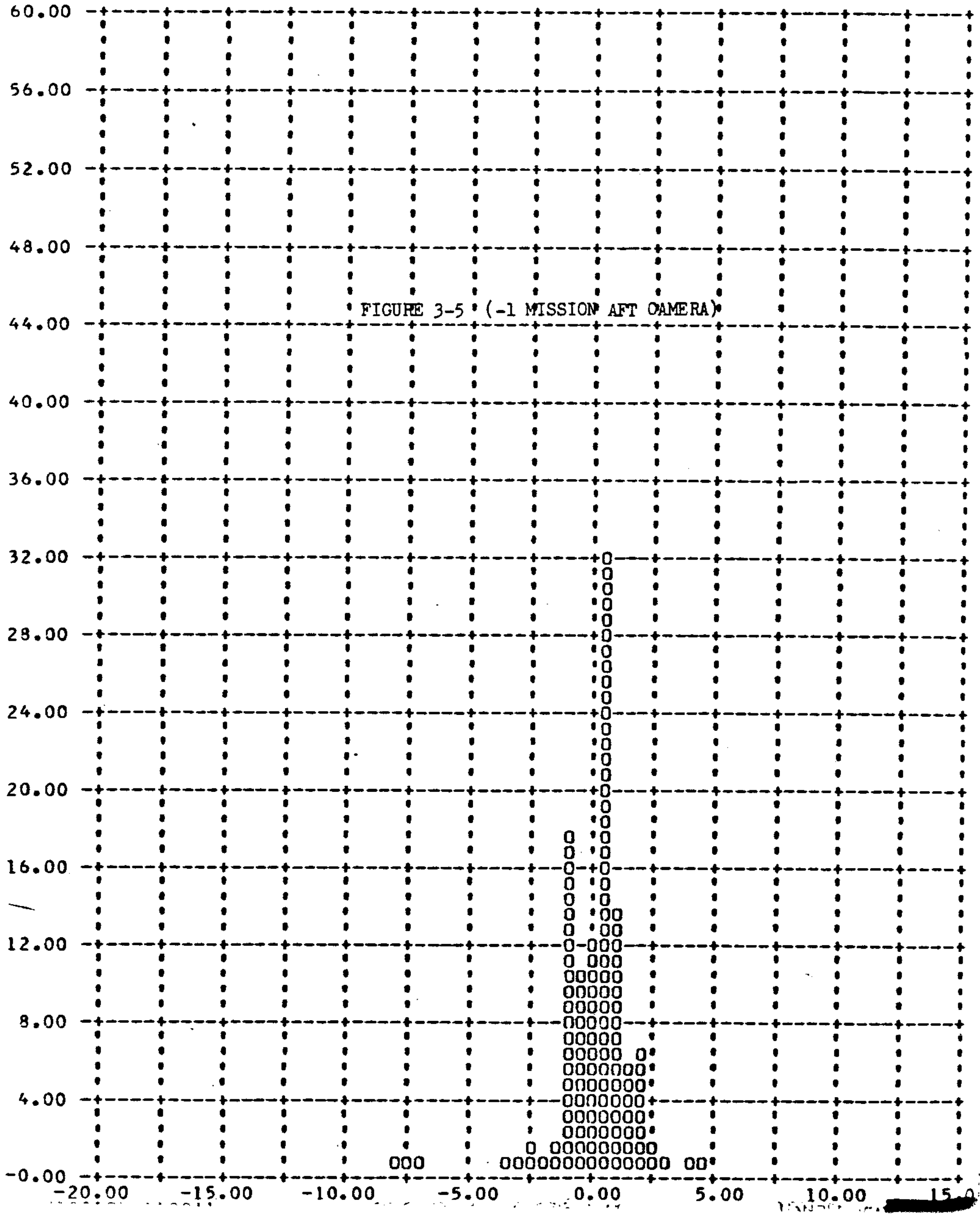
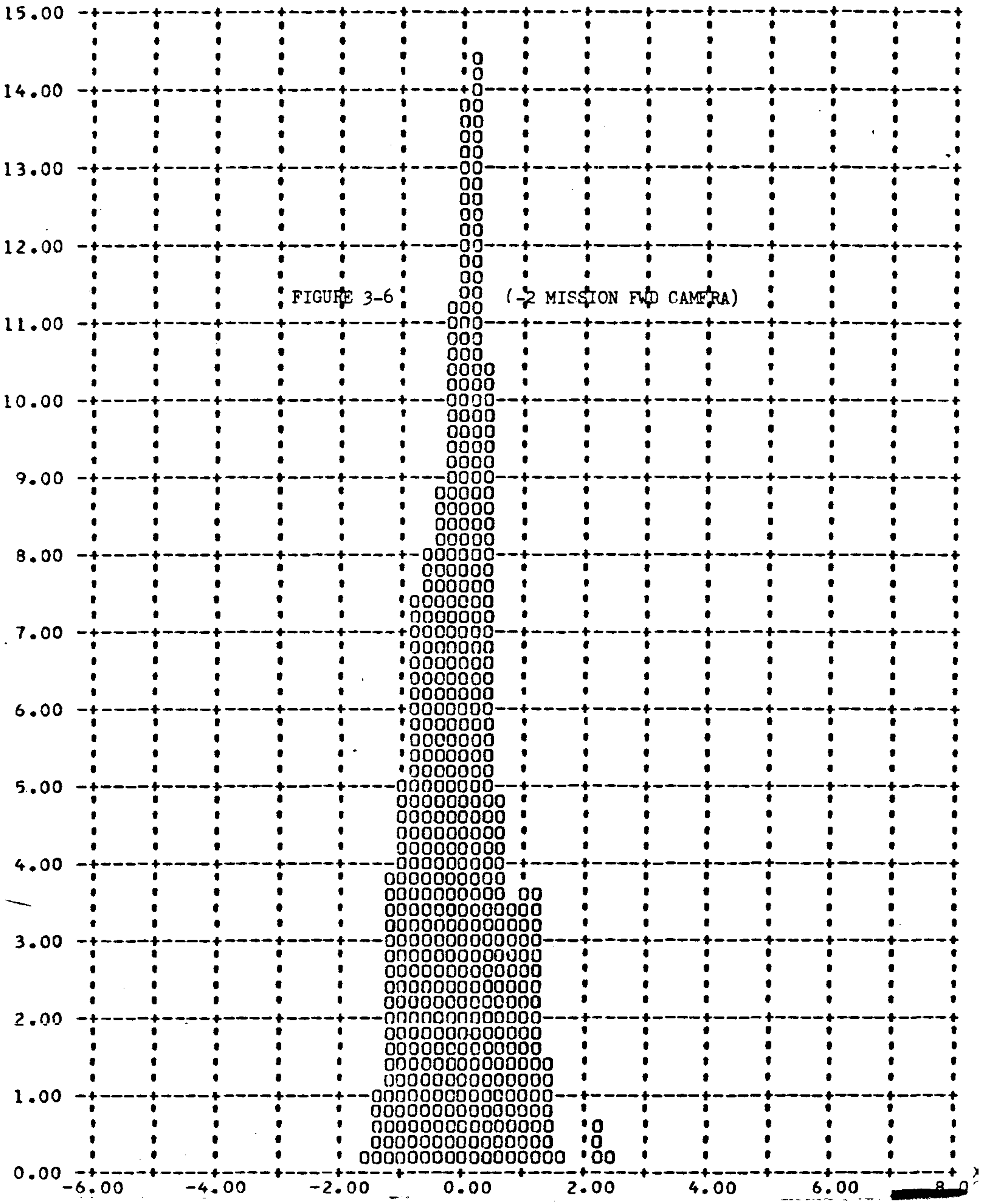



FIGURE 3-5 (-1 MISSION AFT CAMERA)

[redacted]

FRAMES 1-3 OF EACH OP OMITTED 90 PERCENT = 1.13

Y V/H RATIO ERROR - PERCENT (X) VERSUS FREQUENCY - PERCENT (Y)



FRAMES 1-3 OF EACH OP OMITTED 90 PERCENT = 1.12

V/H RATIO ERROR - PERCENT (X) VERSUS FREQUENCY - PERCENT (Y)

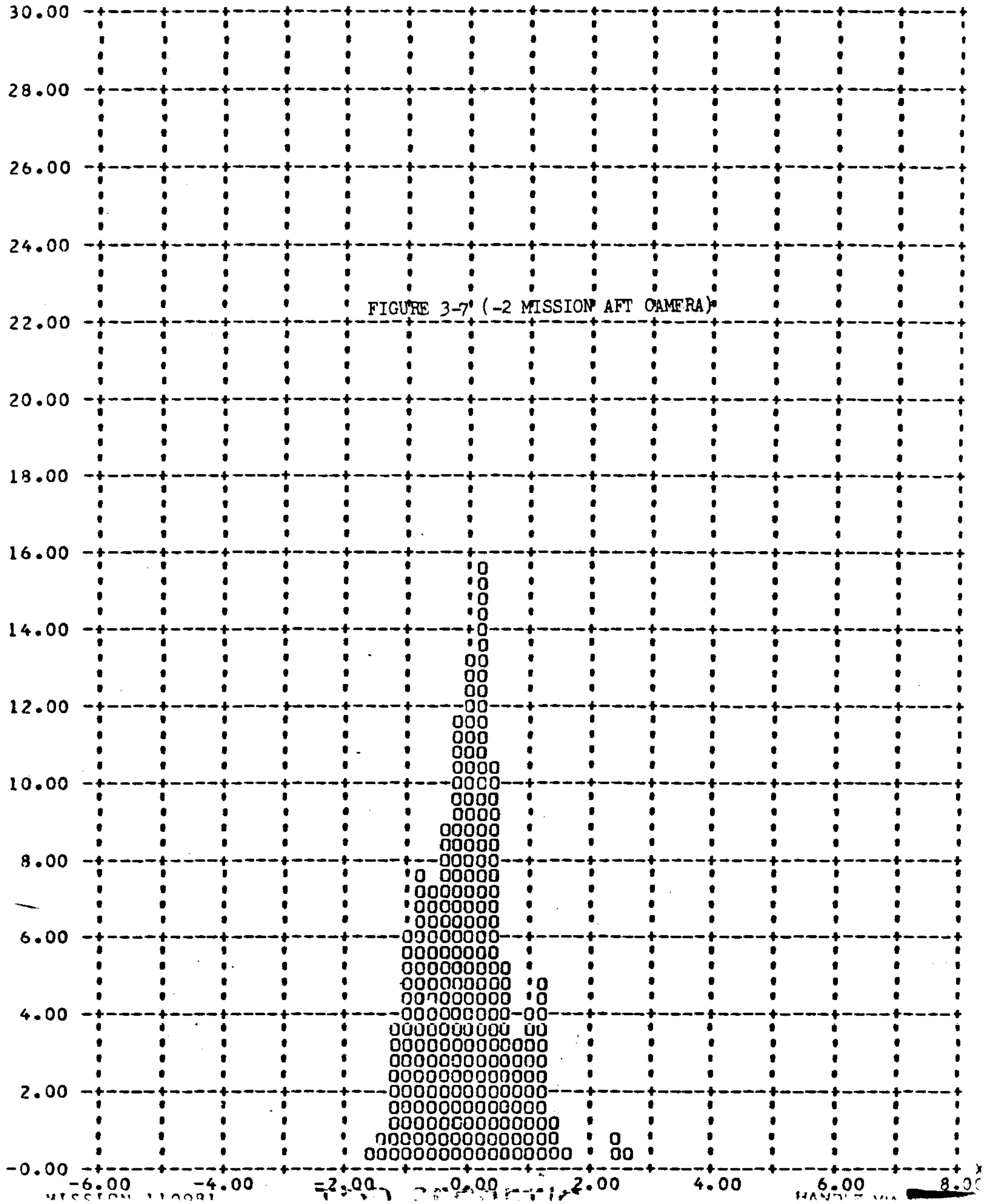



FIGURE 3-7 (-2 MISSION AFT CAMERA)

H. CLOCK SYSTEM PERFORMANCE

The clock system operated normally throughout both missions. Good correlations between clock and system time was obtained with the second order fit data recommended for time correlation. Correlation equations and constants were as follows:

First Order Fit

System Time = $A_o + A_1$ (clock time)

where

$A_o$ = 166297.04306 A1 = 0.9999998169647

Sigma = 0.00308547 No. of points 404

Second Order Fit

System Time = $A_o + A_1$ (clock time) + $A_2$ (clock time)$^2$

where

$A_o$ = -166297.05489 $A_1$ = 0.9999998476421

$A_2$ = -0.537737881844840-13 Sigma = 0.00123341

No. of points 404

I. PMU SYSTEM OPERATION

The PMU system utilized a dual bottle without a pulsing network. The surge valve controller timer (large orifice, time A) was reset to 1.3 seconds "on time" with the small orifice "on" continuously. The gas consumption was 4.4 lbs/min.

The PMU system operated satisfactorily throughout the flight and approximately 1500 psi remained at the conclusion of the -2 mission.

[redacted]

J. THERMAL ENVIRONMENT

The temperature data obtained during flight indicated that the temperature environment was slightly cooler than was predicted for the -1 mission. The -2 mission followed the lower end of the temperature vs beta angle prediction curve (refer to Figures 3-8 to 3-10). The average temperature for both cameras was 64° and remained almost constant throughout the mission.

K. RECOVERY SYSTEM PERFORMANCE

The -1 mission capsule was successfully recovered by air catch during Rev 115; all re-entry events were within tolerance. The impact was within tolerance although 40 miles north of predicted.

The -2 mission capsule was successfully recovered by air catch during Rev 309. All re-entry events were within tolerance as well as the impact.

L. SRV TAPE RECORDER SYSTEM

During the processing of the -1 mission SRV tape recorder, the ADAPS processor experienced a high loss of sync. This loss of sync was present on both Digital Data 1 and Digital Data 2.

The tape recorder in the -2 mission performed satisfactorily. A total of 237 minutes of data was recorded and processed from the two recorders.

M. POST EVENT 2 TESTING

Post event 2 flight testing consisted of activating the camera system on alternate revs to produce a heavy current load in order to deplete battery and monitor solar array power prior to vehicle re-entry. Heavy load was applied continuously from Revs 338 through 355. During Rev 355, the battery voltage dropped below 22 volts and the vehicle was stable and all systems operational.

The vehicle re-entered on 26 March 1970 during Rev 357. The point of impact was 12° south and 41° west.

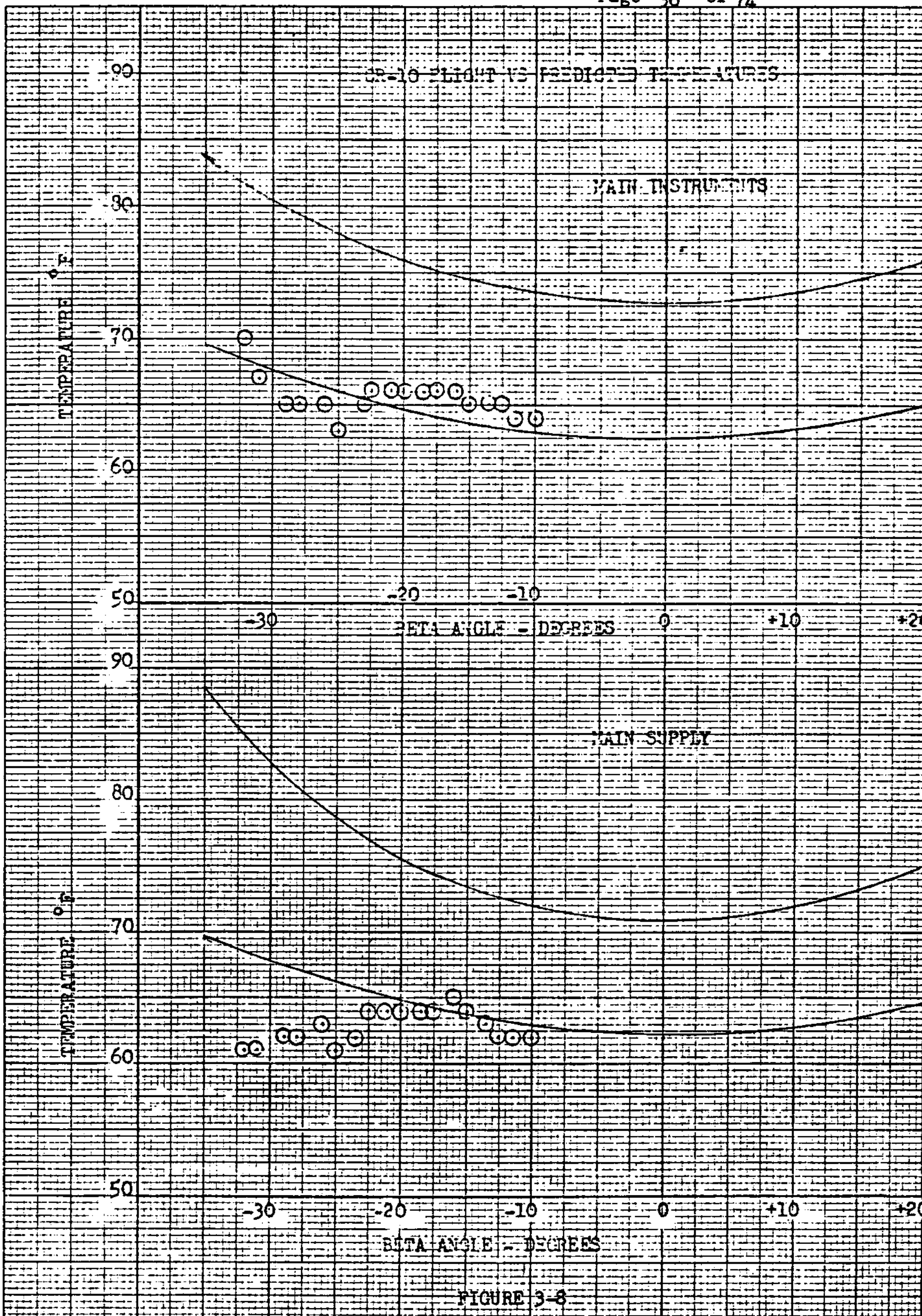

CR-10 FLIGHT VS PREDICTED TEMPERATURES
MAIN INSTRUMENTS
TEMPERATURE °F
90
80
70
60
50
-30
-20
-10
0
+10
+20
BETA ANGLE - DEGREES
MAIN SUPPLY
TEMPERATURE °F
90
80
70
60
50
-30
-20
-10
0
+10
+20
BETA ANGLE - DEGREES

FIGURE 3-8

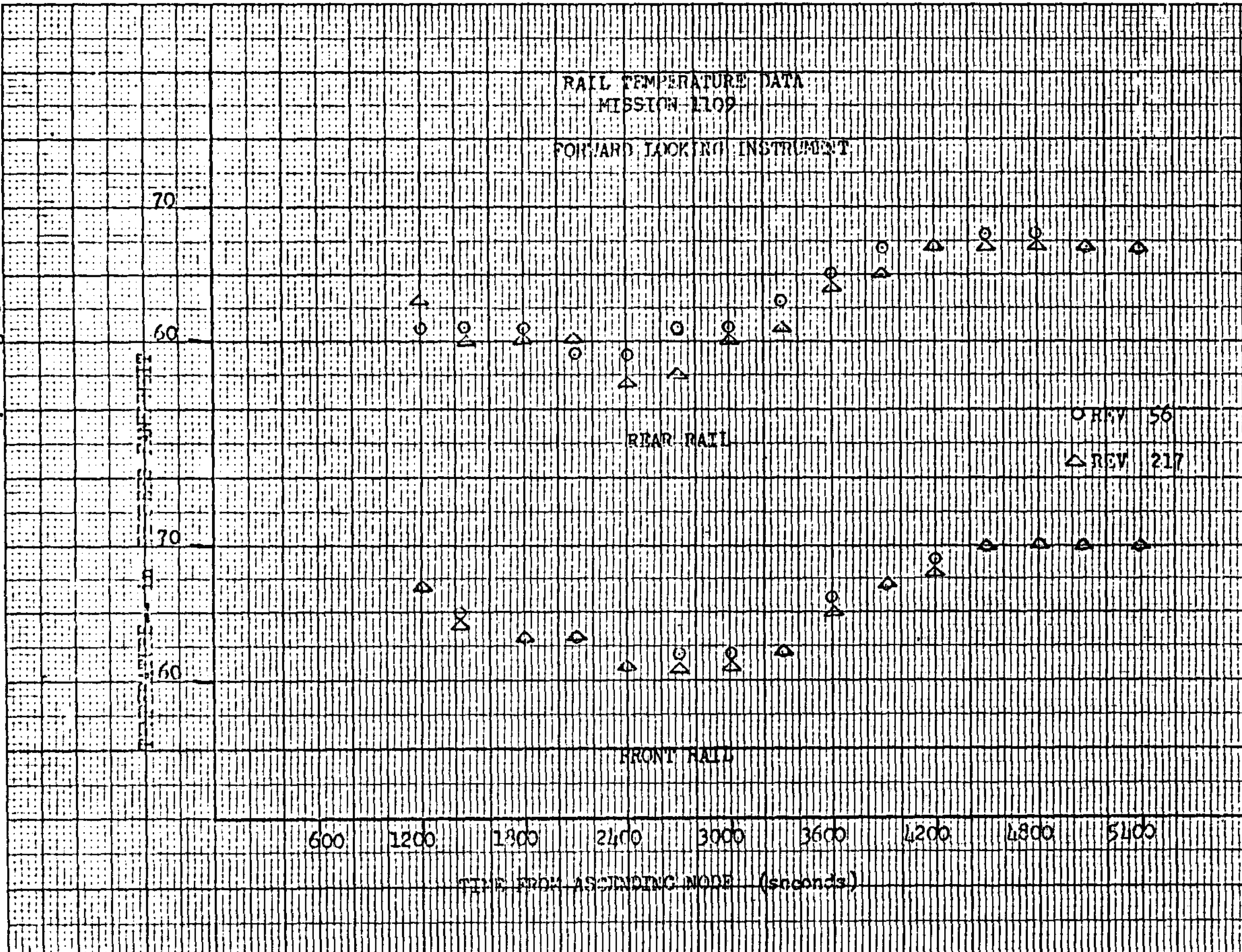

RAIL TEMPERATURE DATA
MISSION 1109
FORWARD LOOKING INSTRUMENT
70
60
REAR RAIL
70
60
FRONT RAIL
O REV 56
△ REV 217
600
1200
1800
2400
3000
3600
4200
4800
5400
TIME FROM ASCENDING NODE (seconds)

FIGURE 3-9

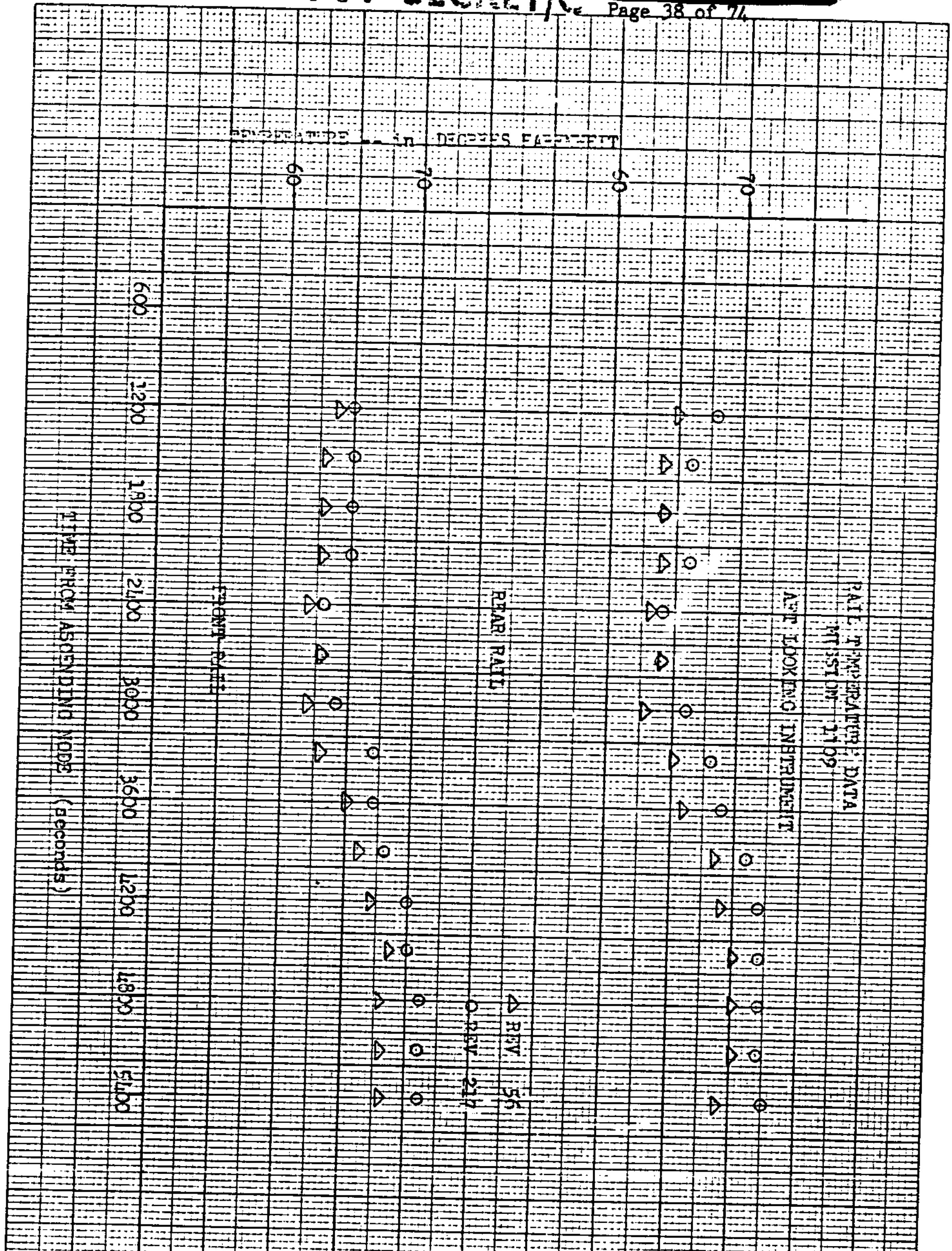

RAIL TEMPERATURE DATA
MISSION 1109
AFT LOOKING INSTRUMENT
in DEGREES FAHRENHEIT
60
70
60
70
FRONT RAIL
REAR RAIL
REV 56
REV 217
600
1200
1800
2400
3000
3600
4200
4800
5400
TIME FROM ASCENDING NODE (seconds)

FIGURE 3-10

N. RADIATION DOSAGE

Each recovery system on Mission 1109 carried a sealed packet of types 3401 and Royal X-Pan film to determine total radiation received at the total cassettes. When the irradiated film packets were developed and their densitometric values compared with pre-flight samples, the levels were found to be below those which would degrade the photography.

The following are the results of the radiation level equivalents:

| Emulsion | Mission 1109-1 | Mission 1109-2 |
|---|---|---|
| 3401 | 0.20R | 0.40R |
| Royal X-Pan | 0.40R | 0.50R |

SECTION 4

PHOTOGRAPHIC PERFORM

A. SUMMARY

The Mission Information Potential (MIP) ra 10 on Mission 1109-1 places this mission segment among the three hig the Corona program. When it is considered that the operational alti the other top rated missions was lower this peak performance is pa ly notable. Unfortunately, the mission was also characterized by a high deg variability of image quality.

A lower MIP rating of 100 was assigned to -2 mission segment, however the overall quality of this mission seg not significantly less.

The DISIC terrain photography was the firs processed with dual gamma chemistry. The maximum film load, nearly 2200 produced the best quality imagery observed from such a system to date. E llar cameras produced good quality imagery with about 30 stars present in rmats and 20 stars present in starboard formats. There was some degradati oth DISIC films from electrostatic marking.

The following footages and exposed frames w covered from Mission 1109.

| Mission | Camera | Film | ge | Frames |
|---|---|---|---|---|
| 1109-1 | Forward | 3404 | 2 | 3005 |
| | Aft | 3404 | 4 | 3010 |
| | Stellar | 3401 | 0 | 2406 Stbd. |
| | | | | 2401 Port |
| | Terrain | 3400 | 4 | 2414 |
| -2 | Forward | 3404 | 3 | 3046 |
| | Aft | 3404 | | 3030 |
| | Stellar | 3401 | | 2780 Stbd. |
| | | | | 2779 Port |
| | Terrain | 3400 | | 2695 |

B. PANORAMIC CAMERAS

1. Image Quality

The overall quality of imagery from the panoramic cameras was highly variable, ranging from outstanding to poor. The best imagery of this mission approached but did not equal the best ever obtained with a J-3 system. Average quality was better than a nominal J-3 performance. Photo interpretation suitability was reported by users to range from fair to good. Variability in quality was caused by focus variation in the formats as well as variations in scale (vehicle altitude) and atmospheric conditions.

This was the first time that third generation lenses had been flown in both pan cameras. Although imagery from the aft camera was generally comparable with that of the forward camera, the latter camera showed a small but consistent superiority. This relationship is consistent with preflight system resolution test performance. The extent of variability in both cameras is directly related to their having third generation lenses. While these lenses have a considerable improvement in peak focus resolution, their off-peak focus resolution drops rapidly. Thus slight variations in film lift that are inherent in the system design may result in large variations in image quality.

A systematic variation in image quality across the formats of both cameras is regarded as a system characteristic. As has been the case with other systems, the imagery along the time track edge tended to be less sharp. Generally, however, the imagery was of good quality and better examples retained their quality at 50 X magnification.

The MIP rating of the -1 mission was 110, while that of the -2 mission was 100. The variation in rating of the two mission segments was not representative of overall performance. Overall quality of the two segments appeared to be equal. The cause of the lower rating for 1109-2 appears to be due predominently to atmospheric conditions of the 1109-2 MIP frame. A secondary factor was a five percent smaller scale.

Controlled Range Network (CORN) targets acquired on three engineering operations through the flight were evaluated. All three operations acquired coverage by both cameras of mobile targets including 51-51 T-bar and Vernier T-bar arrays. Additionally, fixed targets at Ft. Huachuca and Edwards AFB were acquired on two of the same engineering operations. The average observations of three readers are summarized in Table 4-1. It is apparent that the superiority of the forward camera over the aft camera that was observed during system test was maintained in flight. The level of flight performance of both cameras is also consistent with test results.

Since this was the first mission to have both pan cameras use third generation lenses, it was planned to compare the results of each camera using both Wratten 23A and 25 filters. The third generation lens is designed for use with the Wratten 25 filter. From both theoretical and experimental data, it was suspected that a small but detectable loss of image quality might occur with the shorter wavelength transmission of the Wratten 23A filter. Primary filters were W-25 and W-23A for the forward and aft cameras respectively. Alternate filters were W-23A and W-25. Special arrangements of the exposure slits allowed proper exposure adjustments for both snow and no snow conditions

TABLE 4-1

VISUAL EVALUATION OF BAR TARGET IMAGERY FROM ENGINEERING OPERATIONS

| Camera, Rev, Frame # | Ground Resolution FMC/Scan (feet) | Geographic Location | Universal Grid X | Coord. Y | Target Type - Contrast | Weather Conditions |
|---|---|---|---|---|---|---|
| Fwd,D32,007 | 6.4/12.0 | Salome, Az. | 19.8 | 2.3 | T-Bar 5:1 | Clear |
| Same | 7.0/8.0 | Same | Same | | Vernier 5:1 | Clear |
| Aft,D32,013 | 8.0/12.0 | Same | 56.1 | 3.6 | T-Bar 5:1 | Clear |
| Same | 8.5/8.0 | Same | Same | | Vernier 5:1 | Clear |
| Fwd,D145,010 | 8.9/11.2 | Ft.Huachuca,Az. | 57.5 | 3.0 | T-Bar, type A | Clear |
| Same | 8.9/9.9 | Same | Same | | T-Bar, type C | Clear |
| Aft,D145,016 | 9.9/9.9 | Same | 18.1 | 3.1 | T-Bar, type A | Clear |
| Same | 11.2/12.7 | Same | Same | | T-Bar, type C | Clear |
| Fwd,D210,004 | 12.0/12.0 | Delano, Ca. | 22.5 | 1.0 | T-Bar 5:1 | Scattered clouds/haze |
| Same | 7.5/NR | Same | Same | | Vernier 5:1 | Scattered clouds/haze |
| Aft,D210,010 | 12.0/12.0 | Same | 52.3 | 5.3 | T-Bar 5:1 | Scattered clouds/haze |
| Same | 9.0/8.5 | Same | Same | | Vernier 5:1 | Scattered clouds/haze |
| Aft,D210,011 | 12.0/12.0 | Same | 53.2 | 0.4 | T-Bar 5:1 | Scattered clouds/haze |
| Same | NR/NR | Same | Same | | Vernier 5:1 | Scattered clouds/haze |
| Fwd,D210,010 | 8.9/NR | Edwards AFB | 63.9 | 0.3 | Mil-Std B-1 | Clear |
| Same | 8.9/NR | Same | Same | | Mil-Std B-2 | Clear |
| Same | 12.8/12.8 | Same | Same | | Mil-Std C | Clear |
| Fwd,D210,011 | 8.0/NR | Same | 64.4 | 4.9 | Mil-Std B-1 | Clear |
| Same | 5.7/NR | Same | Same | | Mil-Std B-2 | Clear |
| Same | 12.8/12.8 | Same | Same | | Mil-Std C | Clear |
| Aft,D210,017 | 8.9/NR | Same | 11.7 | 1.2 | Mil-Std B-1 | Clear |
| Same | 6.4/NR | Same | Same | | Mil-Std B-2 | Clear |
| Same | 12.8/14.3 | Same | Same | | Mil-Std C | Clear |

NR = Not resolved

with the alternate filters. Although the alternate filter combination was exercised on several operations, suitable imagery for critical comparisons was not acquired.

An experimental objective of the mission was comparison of the value of photography from a range of altitude. This objective was not achieved because the range of altitude was not achieved and the variable image quality precluded valid comparisons.

2. Data Recording

Both pan cameras produced complete and normal auxiliary data on all of the recovered photography. Imagery of the PG rail holes, scan lines, 200 cycle time marks, slur pulses, camera serial numbers, time words, start of pass marks, and horizon fiducial marks were present and acceptable throughout both mission segments.

3. Anomalies

There are certain anomalies that recur from mission to mission and others that are characteristic of a particular system. While such anomalies have not been eliminated, their effects on flight imagery have been minimized. The CR-10 payload system had fewer anomalies than any previous "J" system.

A crease and associated plus density mark are present in frames 26 and 27 of pass D74 from the forward camera. It begins approximately 15 inches before and extends 36 inches beyond a manufacturing splice located in frame 27. The crease is located on the binary edge in the border area of the film. The crease was caused by riding over a roller flange as a result of mistracking at the splice. This condition is observed occasionally during test with the passage of a splice. No corrective action was required.

Two minus density bands were observed at the extreme takeup end of some aft camera frames. The cause of this anomaly is unknown. The effect is similar to that produced by a hesitation at the start of scan. Since the condition occurs in the bonus area at the end of the format, there was no adverse affect. No action was recommended.

Characteristic anomalies having a minor affect on performance included minor fogging during shutdown periods. The density of fogging was commensurate with the duration of shutdowns. Rail scratches were present along the edge of films from both cameras. The degree and extent of scratching was similar to that observed before the flight. No action was indicated on these characteristic anomalies.

C. HORIZON CAMERAS

Both horizon cameras on both pan cameras functioned properly and produced well-defined imagery throughout both mission segments.

D. DISIC STELLAR/TERRAIN CAMERAS

1. Stellar Cameras

Both stellar cameras functioned properly throughout both mission segments. The orbit and launch time of this mission provided illumination conditions which did not inhibit either stellar camera (actuate capping shutters). Both cameras recorded point-type stellar images. Most port frames recorded more than 30 star images, while 10 to 20 or more star images were recorded by the starboard camera.

Corona and dendritic fog pattern affected the last third of the 1109-1 stellar film and all of the 1109-2 stellar film. The dendritic marks are characteristic of roller flange discharge. The corona marking tended to be more severe on independent operations when the pressure make up system was not operative. Marking in some cases was sufficiently severe as to require additional time to reduce the stellar data. Experience with the DISIC system to date suggests that an effective solution to stellar and terrain marking problems will not be accomplished by adjustments to the DISIC alone, but will require some increase in the environmental pressure.

A few instances of irregular metering were noted in the stellar record of 1109-2. Adjacent frames were sometimes overlapped a distance of about 0.3 inch. It was found that this was normal DISIC operation since if power shut-off occurs at a particular point in the cycle, a partial stellar film transport can occur. The probability of this occurrence is reported to be one in 60 turn-offs. No action was required.

A light leak fog pattern degraded approximately five frames at the end of most stellar camera operations. The density of the fog patterns was commensurate with the duration of camera inoperative periods. The fog pattern was midway between corresponding port and starboard frames and appeared to be the result of improper baffles on the terrain lens vent hole. Vent hole baffling on remaining units is being checked and modified if necessary.

2. <u>Terrain Camera</u>

A maximum load of about 2200 feet of film was exposed in the terrain camera for the first time. The tag end of the 1109-2 segment had a straight manufacturer's cut rather than the serrated cut of the SRV water seal, indicating complete film runout.

The image quality of the terrain camera was the best obtained from such a system. For the first time the terrain film received dual gamma processing. The small percentage of low solar elevation photography precluded an extensive evaluation of the potential advantages expected of this processing. In cases where a wide brightness range was present, it was evident that the information content was better preserved than with previous processing techniques.

Dendritic edge static was present intermittently throughout the 1109-1 terrain film. Corona and dendritic fog patterns were present throughout the 1109-2 terrain film. The marking was less severe on the terrain film than it was on the stellar film because of the lower sensitivity of the former. It appears that an increase in the pressure level will be required to eliminate this problem in future systems.

Several minus density spots occurred repeatitively on the terrain formats. They are apparently caused by emulsion particles adhering to the reseau plate. This minor degradation is a characteristic of the system for which there is no corrective action available.

SECTION 5

PANORAMIC EXPOSURE

A. INTRODUCTION

Panoramic camera exposure is determined by the scan rate, slit width, filter, and scene luminance. Scan rate is adjusted continuously in flight to compensate for forward motion. The patterns of adjustment depend on orbit geometry. Primary and alternate filters are installed before the flight. Four fixed slit widths plus a failsafe slit width are also established in each camera before the flight. The four slit widths may be operated by a preflight adjusted automatic sequence control, or fixed on command in flight.

Scene luminance is a complex variable that is affected by time of day and weather conditions as well as characteristics of the scene itself. For purposes of planning and controlling Corona operations a series of criteria have been developed with basic variables of time of year (month) and the presence or absence of snow cover. Each criterion then provides the luminance (or exposure requirement) as a function of solar elevation. For purposes of setting slit widths and timing the automatic exposure change sequences, the criteria for winter months combine snow and no snow data to provide an average pattern of luminance over the regions of primary interest. During a mission, separate criteria for snow and no snow conditions may then be used on the basis of current weather data to further improve the exposure control. This was the procedure used on Mission 1109 which was flown during the month of March.

Depending on the particular operational and photographic requirements of the mission, orbits, launch date and time, and film and filters are selected. From these data slit widths and automatic sequencing relationships are established to provide the most nearly optimum exposure that can be predicted.

B. SPECIAL OBJECTIVES

1. Multiple Altitudes

Mission 1109 was planned to operate at three different perigee altitudes. After about two days at 82 nautical miles, it was planned to boost to 92 nautical miles. After about three additional days, it was then planned to boost to 100 nautical miles for the remainder of the mission. Since the progressively higher altitudes cause smaller V/h values, smaller exposure slits are required to provide the same exposure at the higher altitudes. It was planned that automatic slit sequences would be effective throughout the mission for low solar elevation conditions but would be designed primarily for use after the fifth day of the mission.

The purpose of the multiple altitude orbit plan was to provide maximum image quality in coverage of a few targets at the beginning of the mission while achieving maximum area coverage for the total mission. It was hoped that the range of image scales with the same cameras would provide insight to the relative merits of maximizing ground detail versus maximizing area coverage. As mentioned in Section 4, the variable image quality precluded significant conclusions.

2. Resolution Effects of Filters.

Since this was the first system to be flown with third generation lenses in both cameras, an opportunity was present for evaluating the effects on resolution from using filters of varying wavelength cutoff characteristics. The third generation lenses were designed for use with Wratten 25 filters which transmit no light below 580 nm wavelength. Shorter wavelengths cause some degradation with this lens. However, filters with lower wavelength cutoffs are desirable because they allow shorter exposure times with correspondingly less image smear. The primary filters were Wratten numbers 25 and 23A for the forward and aft looking cameras respectively. Alternate filters were numbers 23A and 25 respectively. The Wratten 23A transmits no light below 560 nm It was hoped that by using the alternate filters, comparisons of quality could be made without the obscuring effects of illumination differences and inherent individual camera characteristics. Unfortunately, the variability of image quality precluded any significant conclusion on the filter effects.

In order to provide proper exposure for the alternate filter combination and still have effective automatic control in the primary mode, some innovations were required in the use of the exposure control system. The forward camera slit four, normally the widest and first used on descending passes in automatic mode, was the narrowest on this camera to provide the reduced exposure needed with the alternate (W-23A) filter. This forward camera slit was designed to be used with the failsafe slit on the aft camera when that camera would use the alternate (W-25) filter. Location of SPC-51 was adjusted to permit time-out of the slit four position before possible operations when the primary filters would be used in automatic mode.

Another exposure control innovation was the use of SPC-17 to stop the automatic exposure sequence before reaching slit one, the narrowest and last used on descending passes in automatic mode. This arrangement would allow proper exposure with primary filters in automatic mode at the 92 nautical mile altitude and during the first days at 100 miles.

C. OPERATIONAL EXPOSURE

Because of a booster "cold burn" a nominal orbit was not achieved. It was necessary to use two DMU rockets (on revs 3 and 4) to achieve a satisfactory period and perigee height. This resulted in a mean operational altitude of about 93 nautical miles being used until rev 88 when the vehicle was boosted to about 100 nautical miles for the remainder of the mission. In effect, the conditions that had been anticipated for days three, four, and five actually existed for days one through five. The actual flight primary filter exposure profiles for the forward and aft cameras at the 93 mile perigee are illustrated by Figures 5-1 and 5-2 respectively. The upper solid line represents the exposure time requirement for average scenes combining both snow cover data and no snow data. The saddle in the curve represents the transition from snow to no snow as solar elevation increases. The lower solid line represents the exposure time requirement for no snow conditions. The solid lines intersect at about 30 degrees north latitude, where snow has never been encountered in program records. Figures 5-3 through 5-6 illustrate the exposure profiles for the remainder of the mission. Superimposed on Figures 5-1, 5-3, and 5-5 are histograms of frequency of photographic operations for revs 1-80, 81-160, 161-300 respectively. While plotted on forward camera exposure profiles, the data include both cameras. It is apparent that except for the change in altitude at rev 88, the exposure profiles were very stable throughout the mission.

On a daily basis, rev by rev reports of the four-inch snow cover boundary were available throughout the mission. It was found that the best exposure match was usually obtained with fixed slits rather than the automatic mode. Also, when the alternate filters were used, only fixed slit/failsafe combinations could be used. On only two revs throughout the entire mission was the automatic slit sequence programming actually used.

FIGURE 5-1 , EXPOSURE PROFILE, Mission 1109, Payload CR-10

Fwd - Looking Camera #321 , Pass #41

Launched 2215Z, 4 March 1970

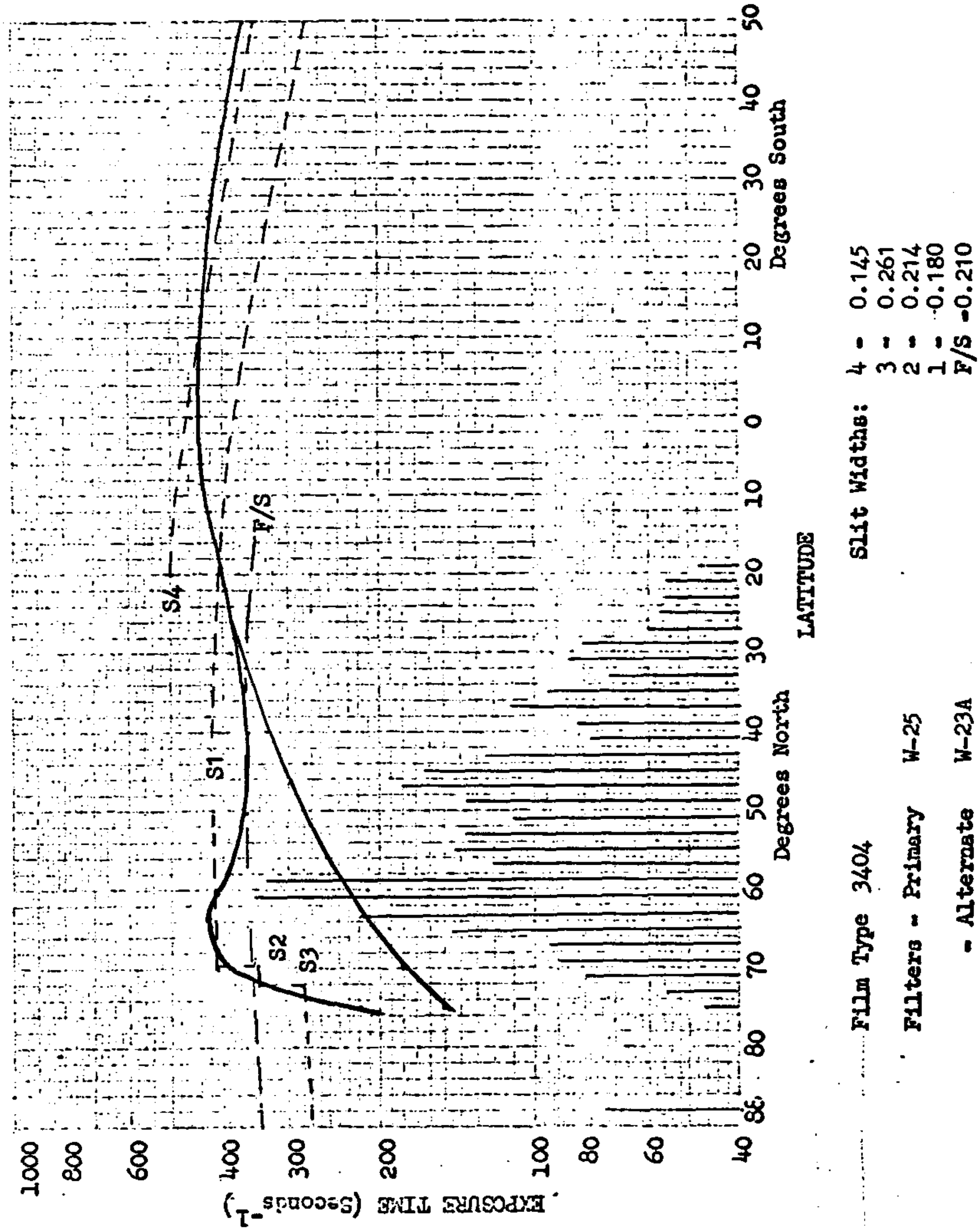


FIGURE 5-2 , EXPOSURE PROFILE, Mission 1109, Payload CR-10

Aft - Looking Camera #320 , Pass #41

Launched 2215Z, 4 March 1970

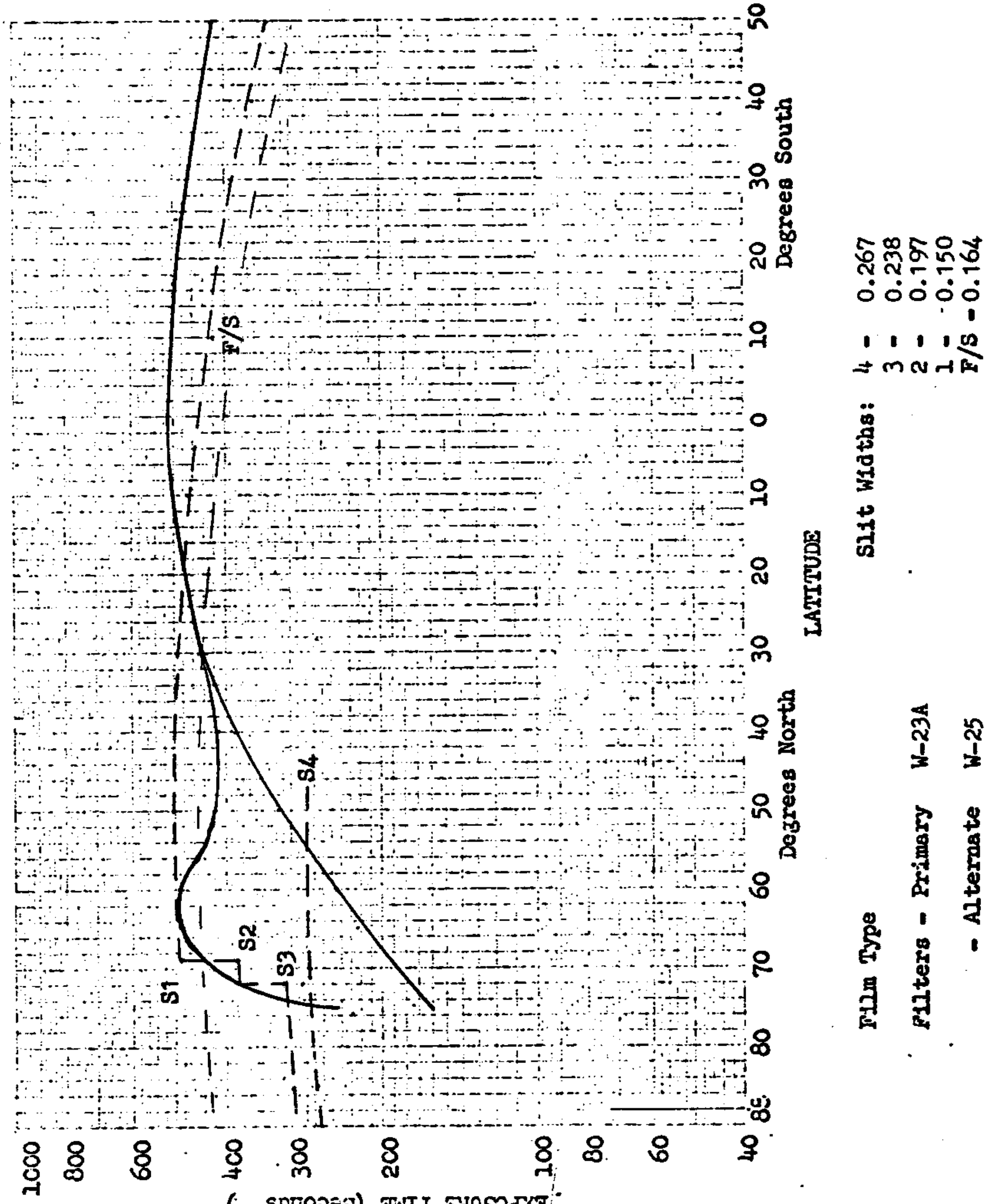


FIGURE 5-3 , EXPOSURE PROFILE, Mission 1109, Payload CR-10

Fwd - Looking Camera #321 , Pass #121

Launched 2215Z, 4 March 1970

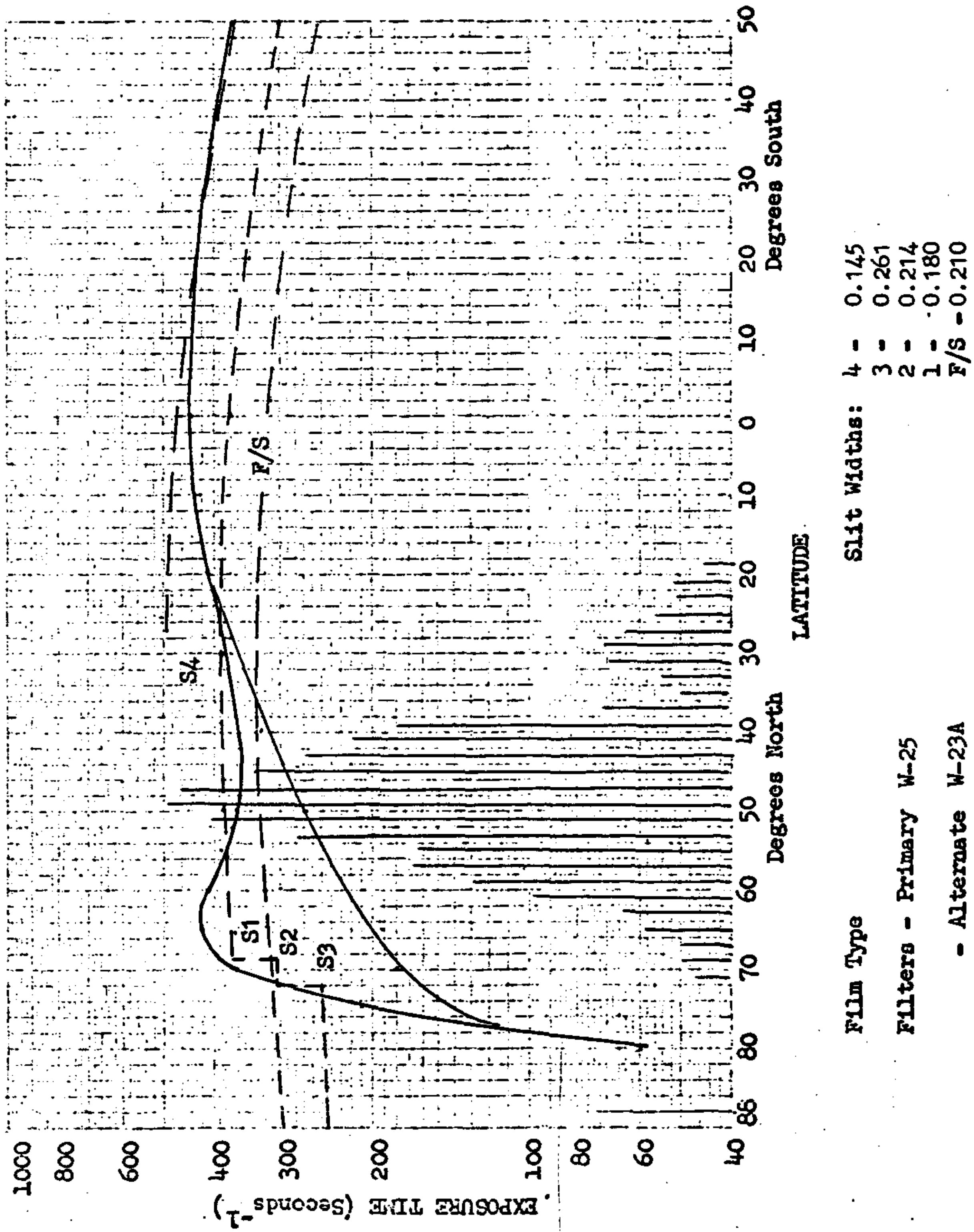


FIGURE 5-4 , EXPOSURE PROFILE, Mission 1109, Payload CR-10

Aft - Looking Camera #320 , Pass #121

Launched 2215Z, 4 March 1970

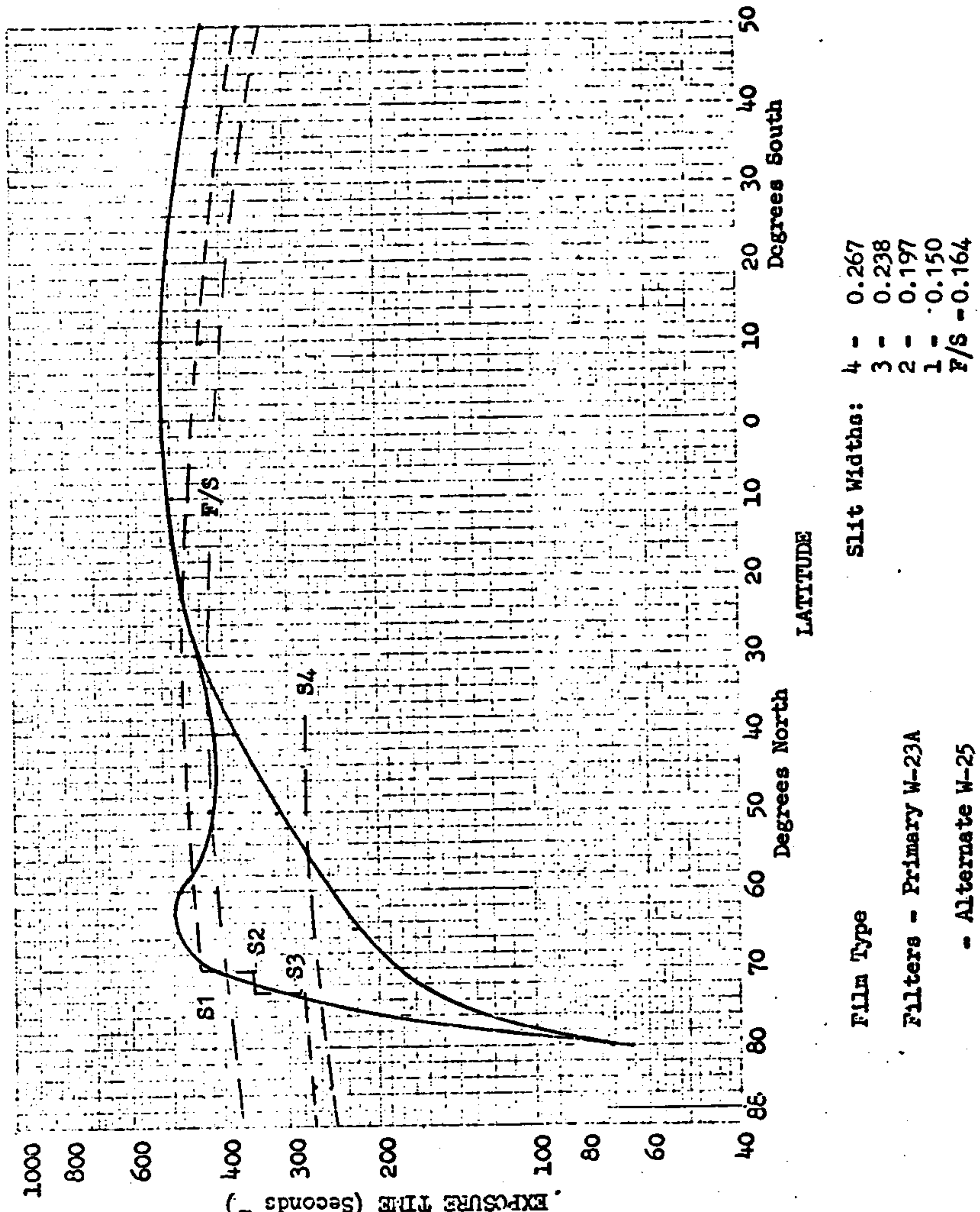


FIGURE 5-5 , EXPOSURE PROFILE, Mission 1109, Payload CR-10

Fwd - Looking Camera #321 , Pass #235

Launched 2215Z, 4 March 1970

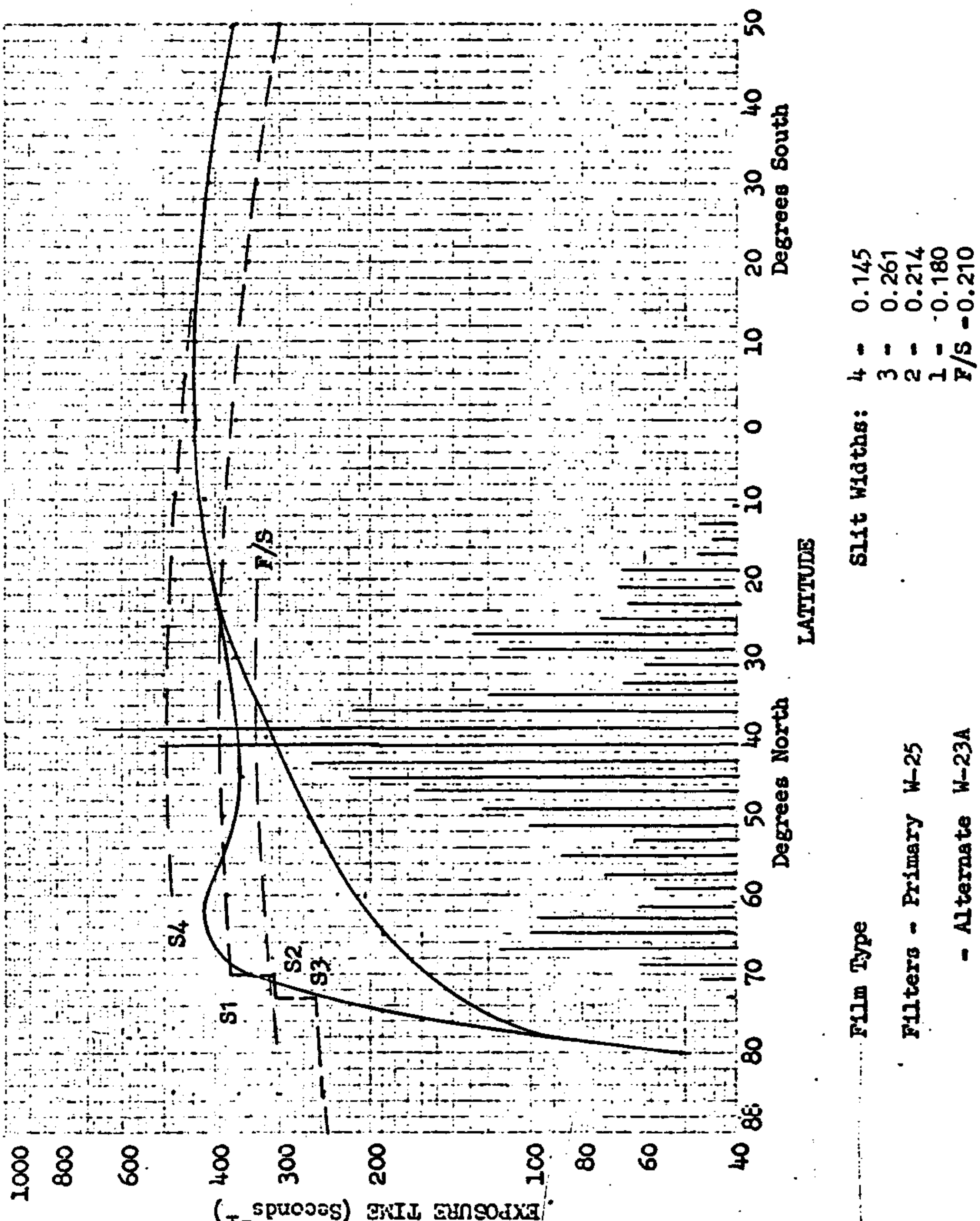
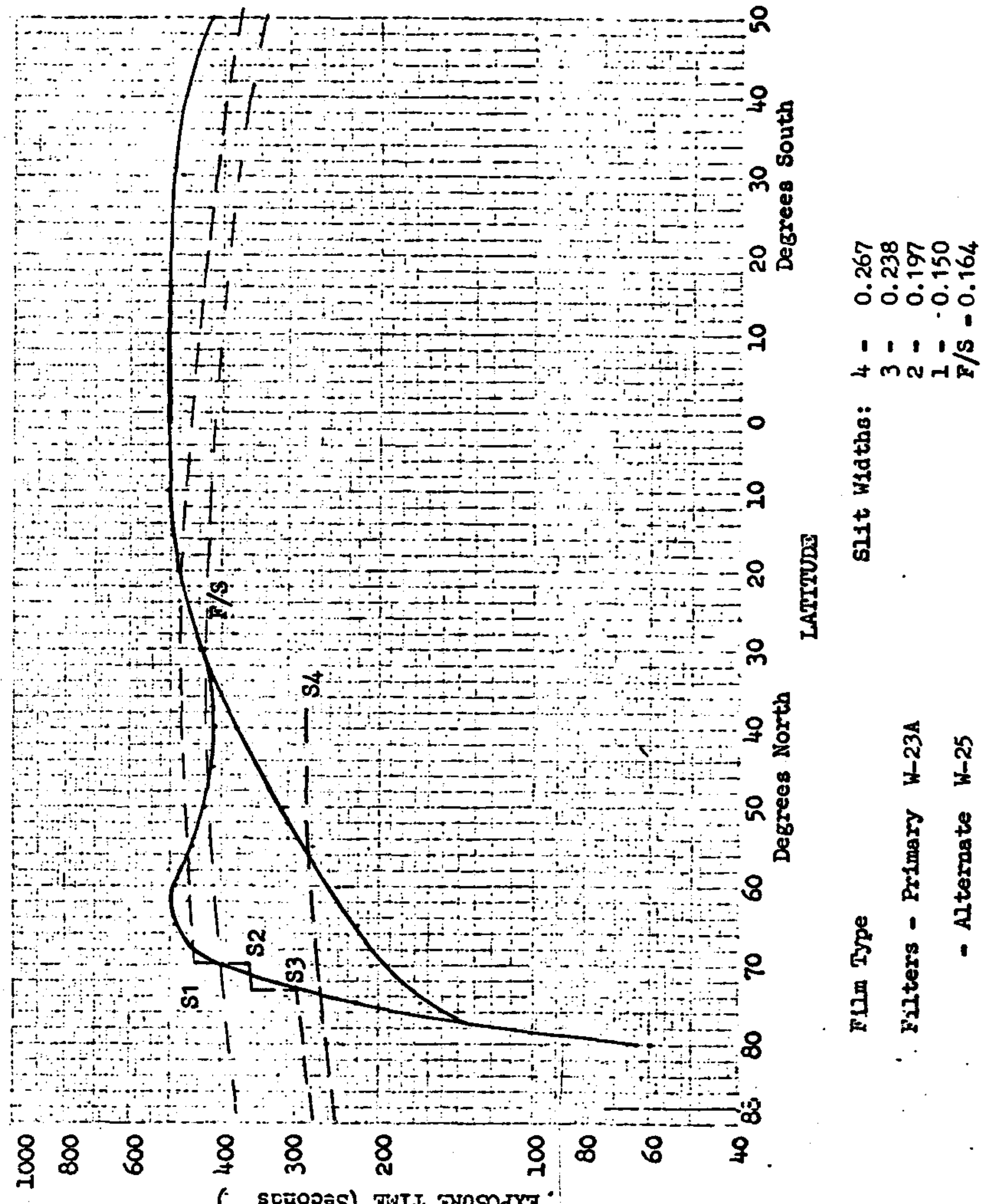


FIGURE 5-6 , EXPOSURE PROFILE, Mission 1109, Payload CR-10

Aft - Looking Camera #320 , Pass #235

Launched 2215Z, 4 March 1970



D. PROCESS CONTROL

All of the Mission 1109 flight films were processed without incident. Dual gamma processing was used on all pan camera film. Using samples of flight film removed before the flight, controlled exposure step tablets were added to the head and tail of each camera film and processed with it to verify process control. The measured densities from the processed step tablets provide a sensitometric curve (D - log E curve) that defines the process performance. The curves for the tablets at the head of each film segment are regarded by the processing facility as the best single estimate of the actual process. These four curves are shown in Figures 5-7 through 5-10. Process results are essentially nominal except for the base fog level which averaged 0.26 rather than 0.20.

E. MACRO DENSITY MEASUREMENTS

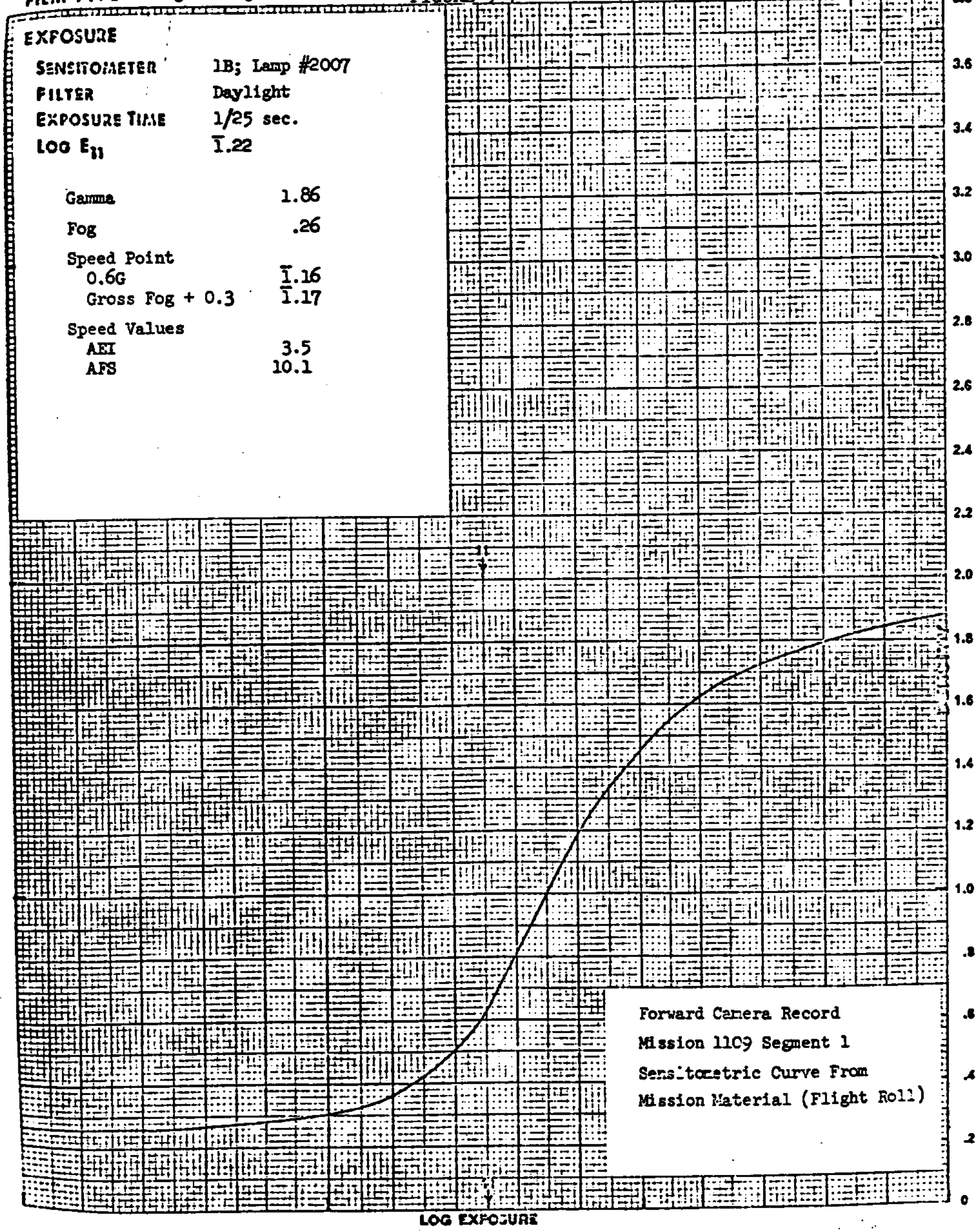
Representative diffuse density measurements are supplied by AFSPPF. These values along with target microdensity measurements are used by Advanced Projects to evaluate exposure performance and improve criteria for future missions.

AFSPPF reported that Mission 1109 was among the best exposed of the 1100 series The frequency distributions of terrain minimum and maximum densities of the forward and aft cameras are summarized in Figures 5-11 and 5-12 respectively.

Starting with Mission 1107, AFSPPF has used the criterion of correct exposure as the total density range being within the 0.25 maximum gamma points of the mission sensitometric curves. These values are calculated from the R-2 sensitometric samples described in the preceeding paragraphs. For the forward camera, this is equivalent to a density range of 0.34 to 1.70; for the aft camera a range of 0.34 to 1.73. Frames whose terrain densities do not fall within this range are characterized as overexposed, underexposed, or exposed beyond the dynamic range of the film. The results of this analysis are shown in Table 5-1.

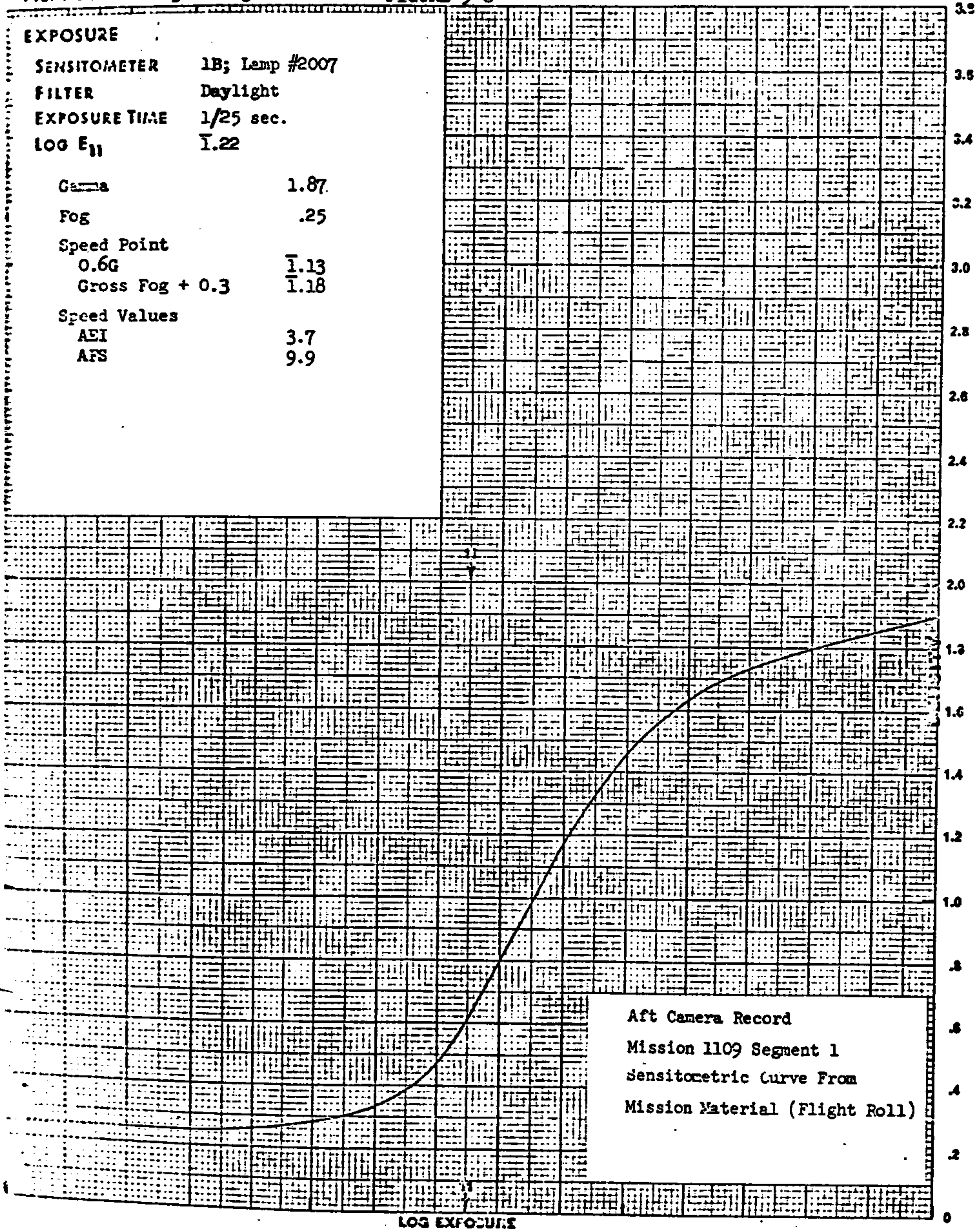
FILM TYPE 3404-443

FIGURE 5-7



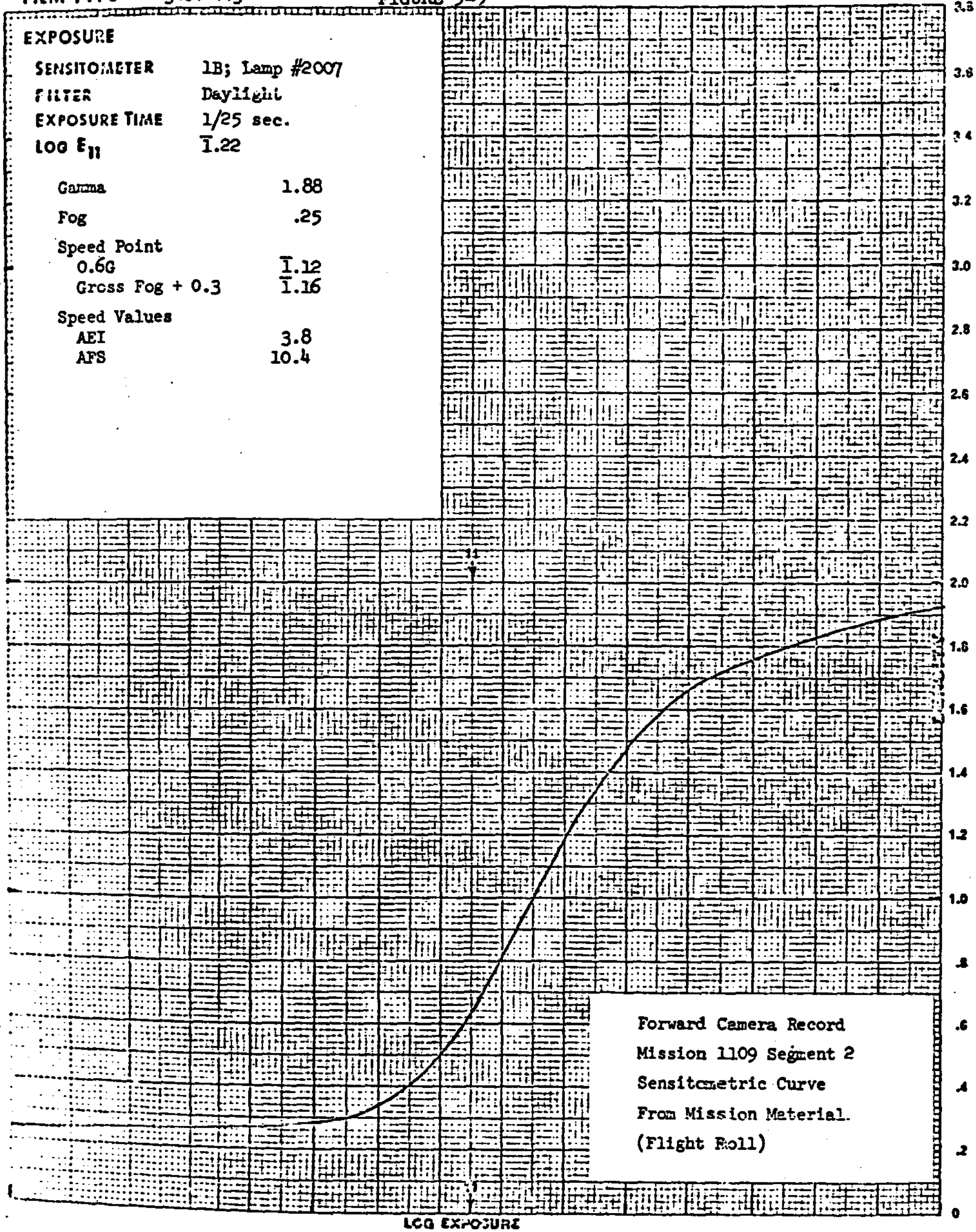
FILM TYPE 3404-443

FIGURE 5-8



FILM TYPE 3404-443

FIGURE 5-9



FILM TYPE 3404-443 FIGURE 5-10

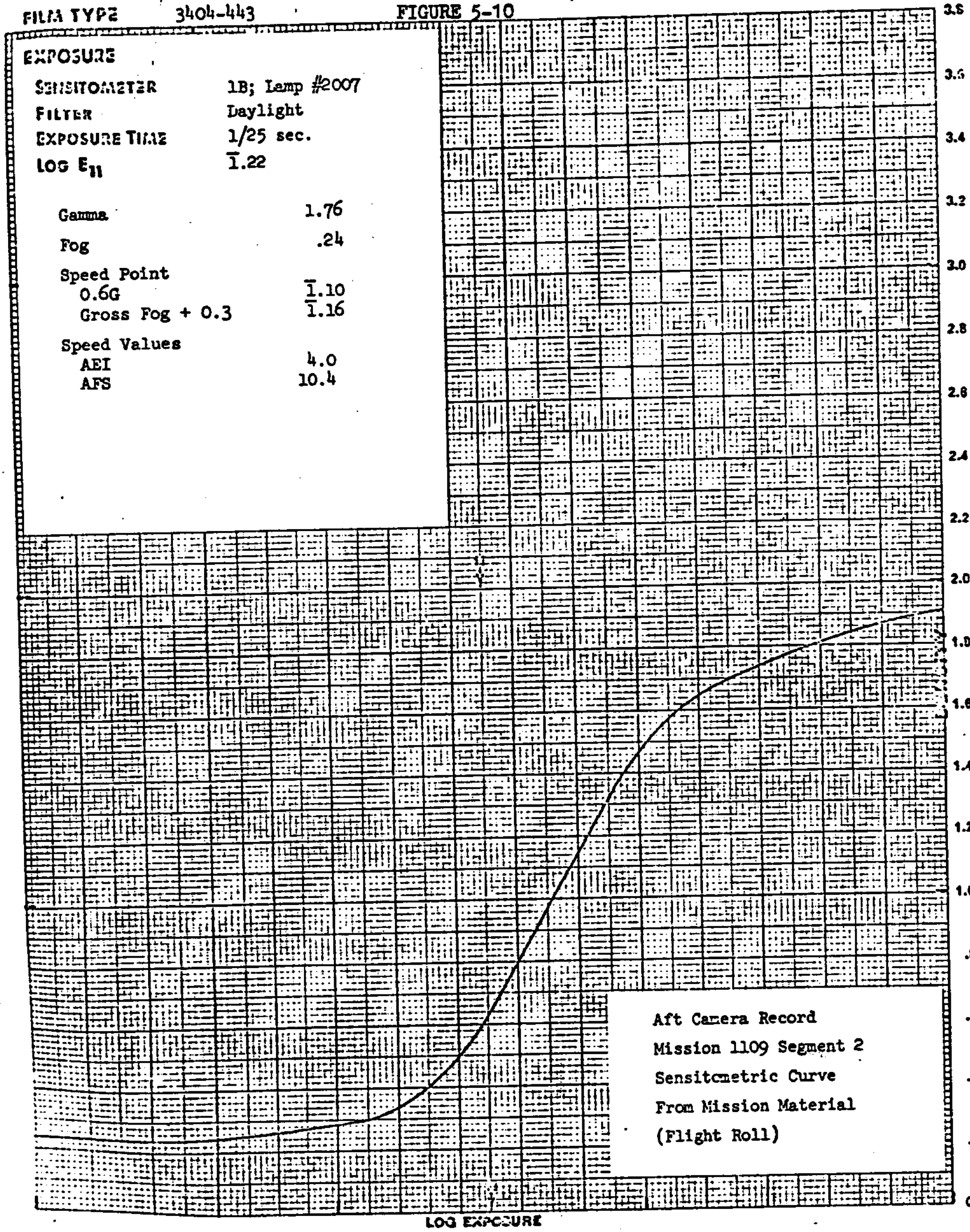
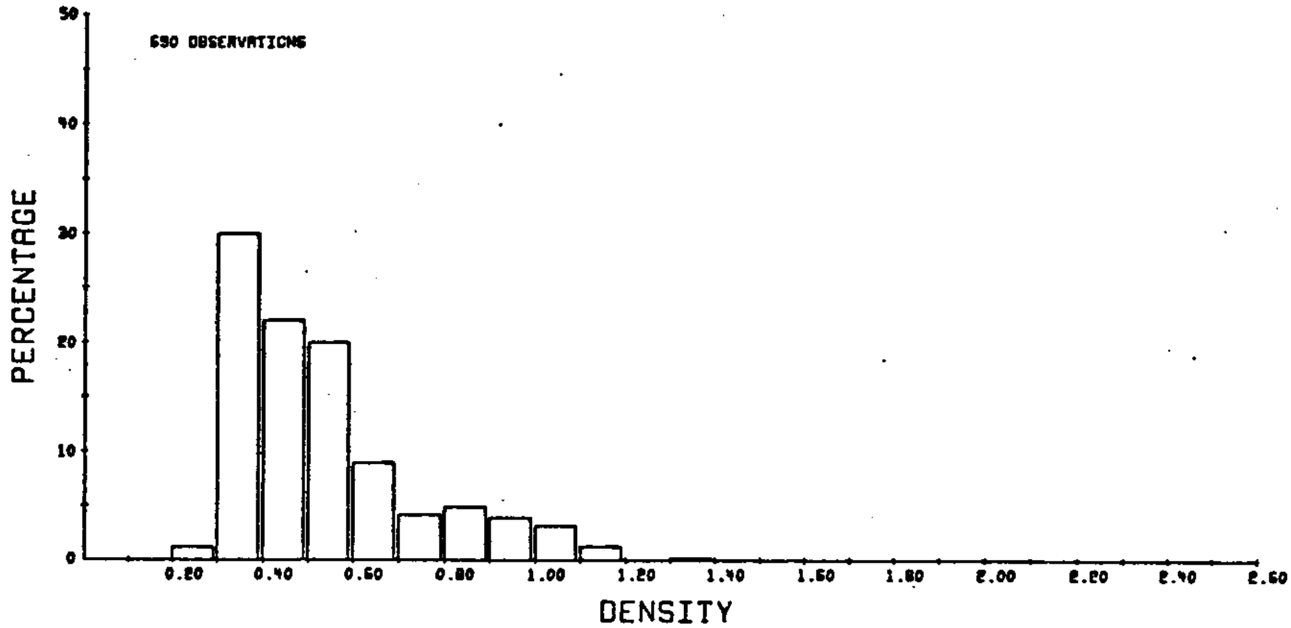


FIGURE 5-11

FREQUENCY DISTRIBUTION - FORWARD CAMERA

DMIN




DMAX

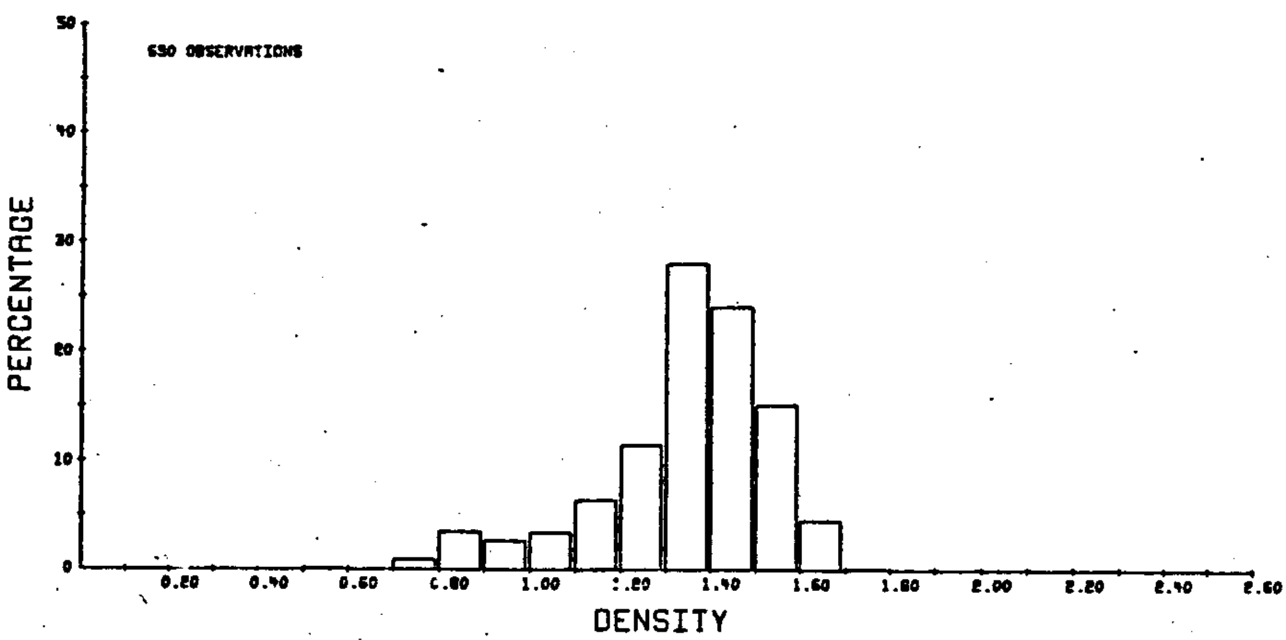
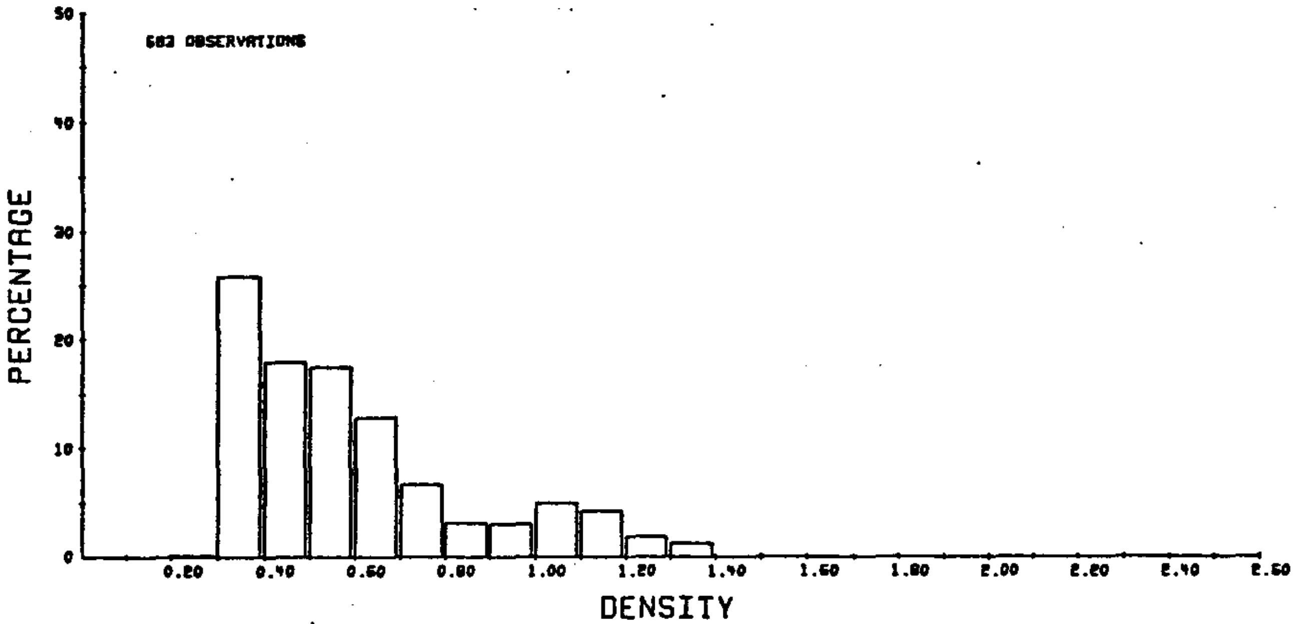


FIGURE 5-12

FREQUENCY DISTRIBUTION - AFT CAMERA

DMIN




DMAX

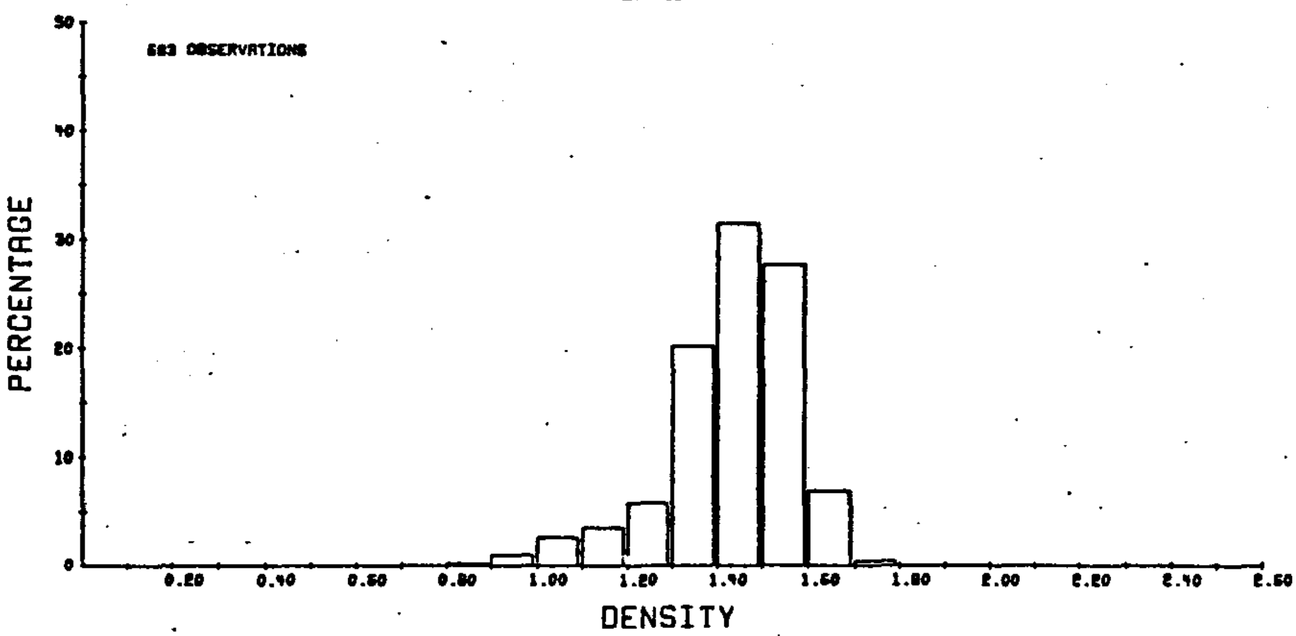


TABLE 5-1: MACRODENSITY EVALUATION

| Camera/Evaluation | Frames | Percent |
| --- | --- | --- |
| Forward Camera | 690 | |
| Within control limits | 625 | 90.57 |
| Overexposed | 1 | 0.15 |
| Underexposed | 64 | 9.28 |
| Exposure exceeds dynamic range | 0 | 0 |
| Aft Camera | 683 | |
| Within control limits | 650 | 95.17 |
| Overexposed | 1 | 0.15 |
| Underexposed | 30 | 4.40 |
| Exposure exceeds dynamic range | 2 | 0.30 |

A check of the raw density data shows that most instances of underexposure involve values that are only one or two hundredths below the 0.34 criterion. The extreme low value for the whole mission was 0.29. It is also found that most cases of underexposure are at locations that had been reported during the flight to be snow covered but are listed in the density records as not having snow. This situation raises questions about the adequacy of either the weather data or the four inch snow depth boundary line. The four inch snow depth has appeared to be a very good criterion in several previous checks as well as at other transitions in this mission. However data is not available to resolve the question for the instances noted.

The difference in percentages of frames within control between the two cameras is probably due to a small error in the filter factor used by Advanced Projects for the W-23A filter. This error is probably less than 0.10 exposure value units in overstating the filter factor. A correct value would have placed the percentage of aft camera frames within control closer to 90 percent. This filter factor question has been observed in earlier missions but has not been adjusted because of the small magnitude and uncertainty of the precise correction.

F TARGET DENSITY MEASUREMENTS

A technique of evaluating photographic exposure performance through microdensitometry of specified operational targets was developed under Project Sunny. The Sunny techniques were applied to Mission 1109 by AFSPPF.

A total of 46 targets were analyzed. Of these, it was recommended that the exposure be increased on two and be reduced on two. An increase of two-thirds of a stop was recommended for two targets. Of these, one met the A/P density criteria but would have been improved by the recommended increase. The other was an unusually dark target (railroad cars) that needed more exposure although the overall scene was correctly exposed.

An exposure reduction of one full stop was recommended for a snow-covered aircraft-on-runway scene which was overexposed per A/P criteria. The reason for overexposure was coverage farther north on the same pass that was reported to have no snow cover. The exposure control system can not accommodate this situation and the best alternative was used The other exposure reduction recommended was one and one-third stops for an unusually bright scene, a missile launcher located in a desert area The smallest slits available were used for this operation and no correction was possible.

It is concluded that the Project Sunny analysis indicated excellent exposure control within the capabilities of the J-3 system.

## SECTION 6

## IMAGE SMEAR

### A. VEHICLE ATTITUDE AND RATES

A "Frame Time And Attitude Date" tape is supplied to Advanced Projects by NPIC. This tape contains the time word for each frame of panoramic photography. It also contains for each frame the pitch, roll, and yaw attitude elements that have been interpolated from the stellar photography of the DISIC. Using either this tape, or time values from the system tape recorder, a computer program at A/P calculates the exposure time of each frame and compares the camera cycle rate with the APF ephemeris to calculate the V/h mismatch (Section 3 D). Then, using the NPIC attitude data for each frame, rates are calculated and combined with the crab error required to compensate earth rotation at the latitude of each frame.

The computer program rejects the first three frames of all operations as the large V/h error on the start-up cycles is not representative of the overall system operation.

Because of a change in the NPIC reference system for yaw angles starting with Mission 1108, the Advanced Projects computations utilizing this value are no longer valid. Until the input and output programming can be made compatible, yaw data and the subsequently derived cross-track resolution data are omitted from this report. An examination of the NPIC raw data and of the photography itself demonstrates that the omitted data does not contain significant anomalies.

The Advanced Projects computer program also plots the frequency distribution of the rates and errors. These plots are not included as a part of this report but are maintained at A/P for reference. Mission 1109 attitude and rate errors are summarized in Table 6-1.

TABLE 6-1

VEHICLE ATTITUDE AND RATE ERRORS*

| Value | Units | Camera | Mission 1109-1 90% | Mission 1109-1 Range | Mission 1109-2 90% | Mission 1109-2 Range |
|---|---|---|---|---|---|---|
| Pitch Error | (degrees) | Fwd | 0.63 | -0.04 to +0.92 | 0.54 | +0.12 to +0.84 |
| | | Aft | 0.53 | +0.14 to +0.84 | 0.63 | 0.00 to +0.92 |
| Roll Error | (degrees) | Fwd | 0.14 | +0.02 to +0.36 | 0.12 | +0.02 to +0.25 |
| | | Aft | 0.12 | +0.02 to +0.25 | 0.15 | +0.01 to +0.33 |
| Pitch Rate error | (°/hr) | Fwd | 38.85 | -85 to +100 | 29.26 | -85 to +95 |
| | | Aft | 29.04 | -85 to +95 | 38.86 | -80 to +100 |
| Roll Rate error | (°/hr) | Fwd | 22.43 | -75 to +85 | 20.82 | -50 to +100 |
| | | Aft | 20.51 | -55 to +100 | 22.14 | -95 to +85 |
| Yaw Rate error | (°/hr) | Fwd | 25.86 | -90 to +90 | 25.92 | -65 to +85 |
| | | Aft | 27.19 | -65 to +80 | 27.01 | -90 to +90 |

*Yaw angle error omitted because of lack of reference system data.

B. SMEAR ANALYSIS

The computed attitude and rate data discussed in the preceeding paragraphs are combined with pan camera geometry to provide measures of potential camera performance at the center of each format. One measure is the percentage error of image motion compensation. The other measure, termed "resolution limit", is equal to 70% of the motion in object space (on the ground) that occurred during the exposure interval. These values, measured in-track and cross-track, approximate the best ground resolution that could be achieved by a camera system of unlimited resolution capability. As noted in the preceeding paragraphs, the reported yaw data is not presently usable. Therefore the cross-track components of resolution limits which utilize yaw angle error are omitted from this report. From analysis of the yaw rate data and the characteristics of the photography itself, it is possible to say with considerable confidence that the cross-track components of resolution limits are comparable with the in-track values summarized in Table 6-2.

TABLE 6-2

IMC ERROR AND RESOLUTION LIMITS*

| VALUE | UNITS | CAMERA | Mission 1109-1 90% | Mission 1109-1 Range | Mission 1109-2 90% | Mission 1109-2 Range |
|---|---|---|---|---|---|---|
| IMC Error | Percent | Fwd | 1.74 | -8.0 to +3.2 | 1.30 | -2.0 to +2.4 |
| | | Aft | 1.83 | -8.8 to +3.6 | 1.73 | -3.0 to +2.0 |
| In-track Resolution Limit | Feet | Fwd | 2.07 | 0 to 8.4 | 1.38 | 0 to 2.6 |
| | | Aft | 2.52 | 0 to 12.4 | 2.34 | 0 to 4.4 |

*Cross-track resolution limit values are omitted because of computational difficulties with input data. Actual cross-track values are believed to be comparable to in-track values. See text for explanation.

TABLE 7-1

ESTIMATED SYSTEM RELIABILITY

| Function | Opportunities To Operate | Failures | Estimated Reliability |
|---|---|---|---|
| PRIMARY | | | |
| Panoramic Cameras | 768,000 cyc. | 4 | 98.19% |
| Pan Camera Doors | 150 msns. | 0 | 99.55% |
| Command & Control | 16,872 hrs. | 2 | 97.37% |
| Clock | 16,872 hrs. | 0 | 99.30% |
| Combined On-Orbit Functions | - | - | 94.51% |
| Recovery System | 121 msns. | 1 | 98.61% |
| SECONDARY | | | |
| Horizon Cameras | 163,000 cyc. | 0 | 99.36% |
| DISIC | 45,167 cyc. | 2 | 75.26% |

included in these calculations. The effect of such adjustments would be to lower the reliability estimate slightly. For example, the original DISIC mission was 4800 cycles (Arbitrarily, the cycle count of the terrain camera is used). With the additional 200 feet of terrain film flown on this mission, the actual terrain cycle count was 5109. If the DISIC mission reliability is based on 5100 cycles rather than 4800 cycles, the reliability is reduced from 75.26 percent to 73.93 percent.

DISTRIBUTION

| Copy No. | To |
| --- | --- |
| [redacted] | [redacted] |